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Task Analysis/Workload (TAWL) User's Guide — Version 3.0

March 1990

Aviation R&D Activity at Fort Rucker, Alabama
Systems Research Laboratory

U.S. Army Research Institute for the Behavioral and Social Sciences

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FOR THE BEHAVIORAL AND SOCIAL SCIENCES

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The Task Analysis/Workload (TAWL) methodology predicts operator workload using the information produced from a task analysis of the system. In addition, the TAWL Operator Simulation System (TOSS) performs all the database management and model execution functions needed to use the method. This user's guide contains a description of the TAWL methodology and instructions for generating a workload prediction model using the TOSS software.

Part I of the guide presents an overview of the TAWL methodology; each of the three major phases of the methodology (Task and Workload Analyses, Model Construction, and Model Execution) is described in detail. A glossary is provided to define the use of many of the terms. Part II presents step-by-step instructions for use of the menu-driven Version 3.0 of the TOSS software. Examples of workload rating scales and TOSS output are provided to support the application of the methodology.

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Task Analysis/Workload (TAWL) User's Guide — Version 3.0

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Human Factors in Training and Operational Effectiveness

FOREWORD

The development of new and existing weapon systems will have an impact on the Army's manpower, personnel, and training requirements. Changes in the technology or manpower used in a system can have considerable impact on the workload of the operator(s). Because high operator workload can decrease system effectiveness, operator workload must be considered throughout the system design process.

Models have been developed to predict the operator workload in a number of Army helicopters. The method used for creating these models is called the Task Analysis/Workload (TAWL) methodology. The TAWL Operator Simulation System (TOSS) has been developed to provide computer support for the methodology. The TAWL methodology is useful for assessing the effect of equipment design changes, mission changes, or manning changes on the workload of the system operator(s). It has been applied both to existing systems and prior to system design.

This Research Product is a user's guide for the TAWL method and the TOSS software. The guide consists of two parts. Part I presents an overview of the TAWL methodology and Part II presents step-by-step instructions on the use of Version 3.0 of the TOSS software. The production of the TAWL User's Guide comes in response to increasing interest in the methodology's application to a broad range of Army systems. This interest emanates from industry, as well as from the Army.

The Systems Research Laboratory is responsible for this product, which was compiled by the U.S. Army Research Institute Aviation Research and Development Activity at Fort Rucker, Alabama. The work was sponsored by the Aviation Systems Command (AVSCOM), St. Louis, Missouri, under a memorandum of understanding entitled "Memorandum of Understanding between AVSCOM and ARI," dated 10 April 1985.

During the summer of 1989, the user's guide was provided to the AH-64, CH-47, and UH-60 Program Offices at AVSCOM and to individuals in the following organizations: U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) Headquarters, Alexandria, Virginia; ARI Research Coordination Office, Alexandria, Virginia; ARI Field Unit, Fort Bliss, Texas; ARI Field Unit, Fort Benning, Georgia; ARI Field Unit, Fort Sill, Oklahoma; ARI Field Unit, Fort Knox, Kentucky; Analytics, Inc., Willow Grove, Pennsylvania; Sikorsky Aircraft, Stratford, Connecticut; and McDonnell Douglas Helicopter Company, Mesa, Arizona. In addition, individual briefings were given to representatives of AVSCOM, ARI, Sikorsky Aircraft, McDonnell Douglas Helicopter Company, and Analytics, Inc. The methodology and computer support are expected to be used to assess operator workload in a number of Army systems.

Edgar M. Johnson

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Dr. D. Michael McAnulty conducted critical reviews of the draft user's guide and provided outstanding editorial support; Ms. Cassandra Hocutt developed the initial Task Analysis/Workload (TAWL) software system to manage the TAWL database and to execute the decision rules for predicting operator workload; and Ms. Nadine McCollim formatted and typed the user's guide.

TASK ANALYSIS/WORKLOAD (TAWL) USER'S GUIDE--VERSION 3.0

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Part I

Task Analysis/Workload (TAWL) Methodology

This user's guide contains a description of the Task Analysis/Workload (TAWL) methodology and instructions for generating a workload prediction model using the TAWL Operator Simulation System (TOSS). Research has demonstrated that the most effective documentation of computer software includes a global overview and detailed step-by-step instructions (Holt, Boehm-Davis, & Schultz, 1989). Accordingly, Part I of this guide presents a global overview of the TAWL methodology and Part II presents step-by-step instructions on the use of Version 3.0 of the TOSS software.

Background

Anacapa Sciences, Inc., under contract to the U.S. Army Research Institute for the Behavioral and Social Sciences, has developed a methodology for predicting operator workload using the information produced from a task analysis of the system. The methodology was originally developed during the concept exploration and definition phase of the system development process for the Army's Light Helicopter Family (LHX) aircraft (McCracken & Aldrich, 1984; Aldrich, Craddock, & McCracken, 1984; Aldrich, Szabo, & Craddock, 1986). Analyses were conducted to compare the operator workload of one- and two-crewmember configurations of the LHX. Subsequently, the methodology was refined for use in predicting the effect on operator workload of prospective modifications to existing Army helicopters. The refined methodology has been used to predict the crewmember workload for existing and modified versions of the AH-64 aircraft (Szabo & Bierbaum, 1986), UH-60A aircraft (Bierbaum, Szabo, & Aldrich, 1989), and CH-47D aircraft (Bierbaum & Aldrich, 1989). The refined version of the methodology is called the Task Analysis/Workload methodology. In addition, computer support for the methodology has been developed and named the TAWL Operator Simulation System (TOSS). Initial validation of the TAWL methodology is described in a report by Iavecchia, Linton, Bittner, and Byers (1989).

Overview

Development of a TAWL workload prediction model comprises three stages. In the first stage, the analyst performs a task/workload analysis on the system. A prototype mission for the system is identified and then is decomposed progressively into phases, segments, functions, and tasks. The analysis yields a description of the duration and sequence of each task and identifies the crewmember and subsystem associated with each task. The workload analysis is based on a multiple resources theory of human attention (Wickens, 1984) and yields independent estimates of the cognitive, psychomotor, and sensory components of workload (hereafter referred to as workload components) for each task.

The methodology treats each of the resources independently for two reasons. First, though interactions between the components probably occur, adequate definitions of the nature of the interactions do not exist. Of course, different models of the interactions can be tested with further processing of output from the TAWL methodology. Second, even if the interactions of resources could be modeled, the additional detail that results from estimating each component is useful for determining appropriate ways to reduce or redistribute workload among the crewmembers, subsystems, or components. For example, a designer could decide whether additional information should be presented visually or aurally by determining which component had the least amount of workload.

The workload analysis is based upon subjective estimates of operator workload rather than estimates derived through experimentation. Analysts and subject matter experts (SMEs) generate workload estimates by using equal-interval, verbally anchored rating scales that range from 1.0 to 7.0. This approach avoids the expense in time, money, and manpower expected from experimentally deriving estimates of the workload.

In the second stage of the TAWL methodology, the analyst develops a model of each crewmember's actions and interactions by recombining tasks to simulate the behavior of each crewmember during each segment of the mission. Function decision rules describe the sequencing of tasks in functions, and segment decision rules describe the sequencing of functions in segments. It is assumed that the segments can be combined to model the crewmember's behavior during individual phases and for the entire mission.

In the third and final stage of the TAWL methodology, the analyst executes the model to simulate the crewmembers' actions during the operation of the system. The TAWL Operator Simulation System (TOSS) computer software performs the simulation and produces estimates of each crewmember's cognitive, psychomotor, and sensory workload for each half-second of the mission. The estimates of component workload are generated by summing the workload within each component for the tasks that the crewmember is currently performing. An overload threshold is used during execution to produce estimates of the amount of time during the mission that each crewmember is in an overload condition.

Using the TAWL methodology, an analyst can develop a model of a single system and use the model's output to determine:

- times during the mission that have high workload,
- crewmembers that have high workload, and
- components with high workload.

This information, in turn, may enable system designers to reduce or redistribute workload in one or more of the following ways:

- adjust the distribution of tasks during the mission,
- adjust the distribution of tasks among crewmembers, and
- adjust the distribution of work among cognitive, psychomotor. and sensory components.

Similarly, models of two or more systems or design configurations can be used to identify the systems or configurations with higher workload. In addition to the utility described above, models generated using the methodology produce mission time lines and task listings at half-second intervals. This information can be used to evaluate the systems' manning and training requirements.

The methodology is especially useful in the analysis of systems that require the concurrent or random execution of tasks. The predictions for concurrent task performance are obtained by summing workload estimates for each of the tasks being performed. Little insight will be gained in the analysis of systems whose operations are characterized simply by sequential task performance. The effects of time pressure would be expected to be the major source of workload in these situations; however, TAWL cannot dynamically model the situation where less than the optimal time is allotted to the operator to complete the tasks at hand.

The methodology's multidimensional view of human capabilities provides the unique opportunity for the design engineer to identify modifications that shift operator workload from one component to another. For example, technology designed to reduce an operator's need to maintain physical control of system functions often increases the operator's role as a monitor. Thus, advanced technology may decrease operators' psychomotor workload and increase their cognitive workload. Given the limited capacity of human cognitive ability, system designers must avoid shifting all the workload associated with system operations into the cognitive component (or any other single component, for that matter). Thus, this methodology, with its second-by-second estimate of operator workload, allows the design engineer to utilize more readily all of the operators' capabilities and, in turn, to increase system effectiveness.

Each of the three stages of the TAWL methodology is discussed in more detail in the following sections. Examples are taken from an aviation context, but the methodology can be applied to other systems.

Task and Workload Analyses

The first stage of the TAWL methodology consists of two steps. To simulate the man-machine interface, the system's operation must be characterized. Thus, the first step is a top-down analysis of the system to

decompose the system operation into operator tasks. A schematic representation of the top-down task analysis is provided on the left side of Figure 1.

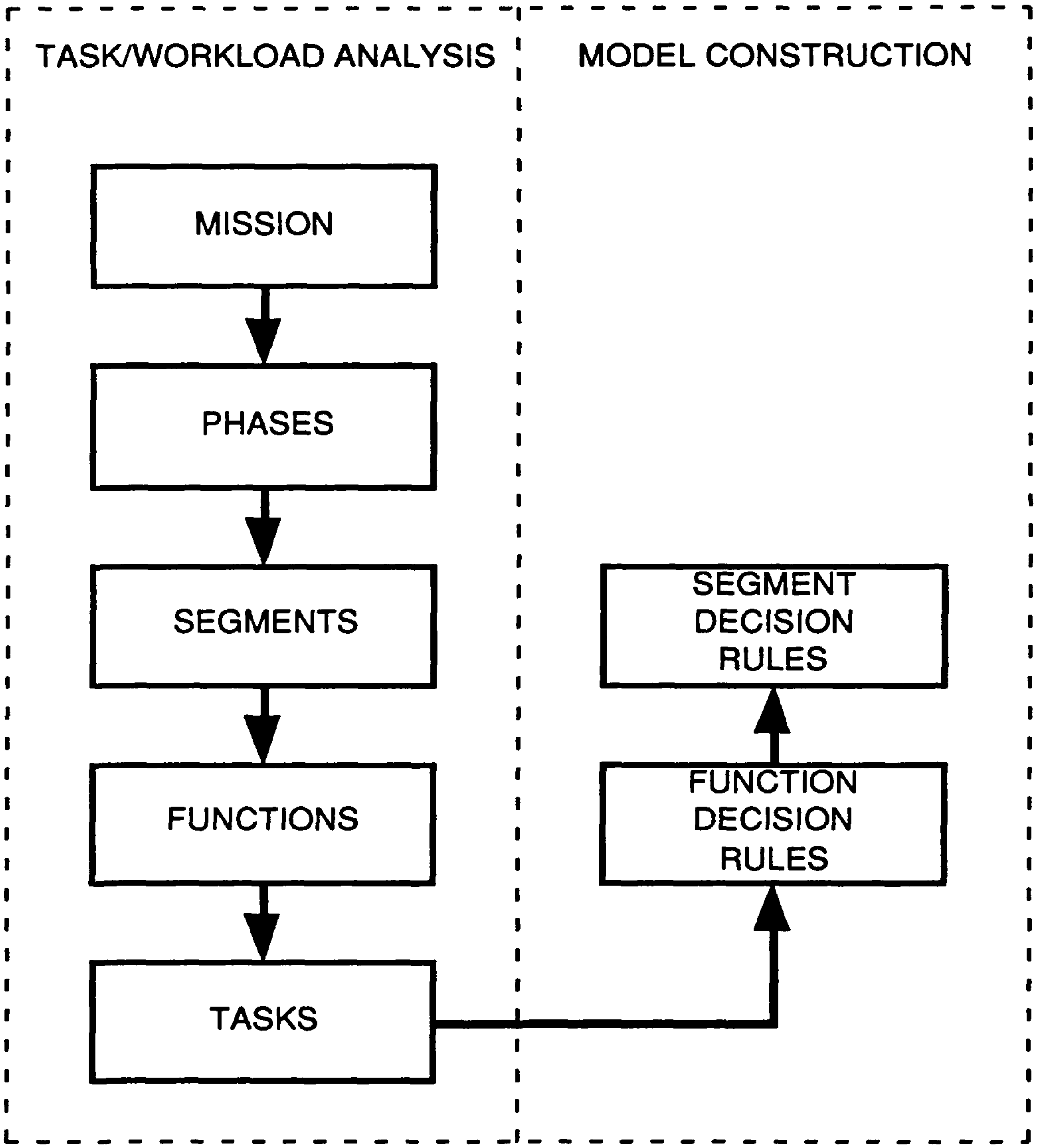

Figure 1. Task/workload analysis and model construction stages.

The second step is a workload analysis. Although the task analysis identifies the tasks required to operate a system, it does not provide sufficient information to predict the workload that the crewmembers experience. To assess the workload imposed by a system, some characterization must be made of the attentional demands that the tasks place on the operators. The sections that follow describe the task and workload analyses in greater detail.

Task Analysis

The task analysis is a top-down decomposition of the overall operation of the system. The steps of the task analysis are listed below and discussed in the pages that follow:

- develop a composite mission scenario,
- divide the composite mission scenario into phases,
- identify the segments in each phase,
- identify the functions in each segment,
- identify the tasks in each function,
- identify the crewmember(s) performing each task,
- identify the subsystem(s) on which each task is performed, and
- estimate the duration of each task.

At the highest level of analysis, each operation of the system, termed a mission, is designed to accomplish an objective. For example, an attack helicopter mission may consist of seeking out and destroying a group of enemy tanks. Because there are several ways to accomplish a mission, a composite mission can be developed from several unique mission profiles (e.g., different routes, different targets). The composite mission is a combination of the unique operations present in the various mission profiles.

After the mission is identified, the top-down analysis continues by dividing the mission into temporally discrete, uninterruptible, and nonrepeating divisions called phases. A phase is a required, logical part of a mission that may be accomplished in several ways. Phases must be sequential to other phases (i.e., they do not occur concurrently) and must be contiguous. All portions of the mission are encompassed under one of the mission phases and every phase must be performed to accomplish the mission. Thus, the mission is composed of a sequence of phases placed end to end. Mission phases identified for the attack helicopter include: preflight, departure, enroute, target servicing, rearming, return, and postflight.

The mission phases are then divided into temporally discrete, uninterruptible parts called segments. A segment represents a particular method of accomplishing a part of a phase. Segments must be sequential to other segments and must be contiguous. Several segments may represent a variety of methods used to complete a portion of the phase; thus, every segment within

the phase may not be needed to complete the phase. Segments may also be repeated in other phases. For example, the enroute phase of the attack helicopter mission contains four segments: contour flight, nap-of-the-earth flight, approach, and landing. Thus, two versions of the enroute phase are accomplished by sequentially performing three of the segments: contour flight, approach, and landing or nap-of-the-earth flight, approach, and landing. Approach and landing are examples of segments that might also be found in other mission phases.

The next step is to identify all the interruptible parts of the segments, which are called functions. A function is defined as the collection of a crewmember's actions that are necessary to carry out a single logical activity. The same functions may be performed in different segments. Functions can be concurrent with or sequential to other functions in the segment. Examples of functions are: change battle position, hover masked, check instrument panel, and fire weapon. For each function identified during mission decomposition, a Function Analysis Worksheet is developed to organize the information gained from the analysis of the function. Table 1 presents an example of a Function Analysis Worksheet taken from the mission of the AH-64 helicopter.

The lowest level of mission decomposition is the task. Tasks are defined as the uninterruptible crew activities that are required for the successful completion of the function. Tasks can be concurrent with or sequential to other tasks in the function. Each task identified in a particular function is listed on the Function Analysis Worksheet for that function. Tasks are described by verbs and objects and are listed in the first two columns of the worksheet (see Table 1). The verb describes the crewmember's action and the object describes the recipient of the action. Examples of verbs include check, set, position, monitor, and release; examples of objects include switches, knobs, helmets, and maps.

For each unique task, three types of data must be determined. First, each crewmember who performs the task is identified in the analysis. A single letter (e.g., Pilot [P], Gunner [G], or Both [B]) in column 3 on the Function Analysis Worksheets indicates the crewmember(s) performing the task. Second, the subsystem equipment associated with the performance of each task is identified. For example, the task "Pull Laser Trigger" is associated with the Laser subsystem and the task "Set Park Brake" is associated with the Brakes subsystem. The subsystems associated with each task are logged on the Function Analysis Worksheet in column 4.

Finally, the time necessary to complete each task is estimated in two steps; each task is first categorized as discrete or continuous and then the duration is determined. Discrete tasks are defined as tasks whose magnitude or intensity of performance does not determine the magnitude of the resulting system change. Discrete tasks occur in open-loop control systems. For a complete review of the definition of open-loop and closed-loop control systems, see Wickens (1984). Activating switches and checking gauges are examples of

Table 1

AH-64 Function Analysis Worksheet

FUNCTION 061 Load Weapons (Rearming) **TOTAL TIME (Approximate) 949 Seconds****

TASKS				WORKLOAD COMPONENTS				
VERB	OBJECT	ID #	SUBSYSTEM(S)	SENSORY	COGNITIVE	PSYCHOMOTOR	SWITCH DESCRIPTION	DURATION (SECONDS) DISCRETE/ CONTINUOUS
Check	MASTER ARM Switch	P396	Weapons (AW)	Visually Inspect Switch Position and Check Light V-2(I)	Verify Current Position Correct (Safe/Light Illuminated) C-2		Toggle - 3 Positions (T-3)	1
Set	TAILWHEEL Switch	P573	Gear (FG)	Visually Scan Switch Positions and Monitor Placement of Switch V-3(I)	Evaluate Position Options and Decide Correct Position (Locked) C-3	Move Switch P-1(L)	Safety Toggle - 2 Positions (ST-2)	1
Set	Park Brake	P455	Brakes (FB)	Feel Brake Position K-2(F)	Decide and Verify Correct Position (Locked) C-3	Push Toe Brakes P-2(F)	Directional Foot Press (FP)	2
Set	Brake Lever	P658	Brakes (FB)	Visually Locate Lever V-4(I)	Make Conditioned Association (Lever Set) C-1	Pull Handle P-2(R)	Push-Pull Handle (PPH)	1
Check	Pylon Safety Pins	G481	Weapons (AW)	Visually Inspect Equipment Status V-2(E)	Verify Correct Status (Pins Installed) C-2		Push-Pull Pin (PPP)	2
Check	PLT/GND ORIDE Switch	G461	Electrical (UEL)	Visually Inspect Switch Position V-2(I)	Verify Current Position Correct (Off) C-2		Safety Toggle - 2 Positions (ST-2)	1
Check	Grounding Cables	G283	Safety (S)	Visually Inspect Equipment Status V-2(E)	Verify Correct Status (Installed) C-2			18
Monitor	Weapons Loading	G641	Weapons (AW)	Visually Inspect Equipment Status V-2(E)	Verify Correct Status (Loading Complete) C-2			3*
Check	Grounding Cables	G283	Safety (S)	Visually Inspect Equipment Status V-2(E)	Verify Correct Status (Removed) C-2			18

*Represents a task that occurs randomly throughout the length of the function; the time reported for the task is the amount of time required to perform the task on each random occurrence.
**The reported time represents an estimate of the average amount of time required to land the aircraft; the actual time spent performing the task on a given occasion may be substantially higher or lower than the reported time.

discrete tasks. No matter how a switch is set (hard, fast, slow, soft), the system's response is the same. Estimates of the duration of discrete tasks are obtained from direct observation during system operation or simulation, or from subject matter experts (SME) interviews. The task duration is logged on the Function Analysis Worksheet in column 9 (columns 5-8 are reserved for the workload estimates).

Continuous tasks are tasks whose magnitude or intensity of performance determines the magnitude of the resulting system response. The resulting state of the system, in turn, determines the continuing magnitude or intensity of the operator's performance of the task. Continuous tasks, therefore, occur in closed-loop control systems. The task of controlling the pitch during contour flight in a helicopter is an example of a continuous task. The pertinent aspect of the system that changes when the pilot pushes forward on the cyclic (stick) is that the aircraft dives toward the ground. If the pilot pushes forward rapidly on the cyclic (high intensity or magnitude) the aircraft dives rapidly (system change). Often mission requirements determine continuous task durations. During a mission, the distance that the pilot is required to fly determines the duration of the task of controlling the aircraft's pitch. Continuous tasks are indicated on the Function Analysis Worksheets either by placing the letter c or the mission-determined duration in column 10.

Identification of the mission, phases, segments, tasks, crewmembers, subsystems, and durations completes the task analysis. The task analysis is performed with support from a number of sources. Task and duration information for existing systems can be obtained from observation of the operation of the system or a system simulation. SMEs, such as operators of existing systems or development engineers of emerging systems, can provide the information necessary to perform the task analysis for systems under development. In addition, useful information may be obtained from checklists, specifications, training and tactics manuals, and other documents that describe the proposed or actual use of the system.

The TOSS software supports the task analysis by providing data base management of the information produced during the decomposition of the mission. TOSS maintains lists of segment names, function names, task names, crewmember names, and subsystem names, as well as a list of the subsystems associated with each task. The subsystems are categorized into major subsystem groups. Thus, the laser subsystem is in the armament subsystem group, along with the fire control computer, gun control, rocket control, and missile control subsystems. The task analysis data can be created, updated, and printed using the TOSS software.

Workload Analysis

As indicated above, knowing what tasks are necessary to operate a system does not provide sufficient information to predict the workload that the crewmembers experience while operating the system. To assess the workload imposed by a system, some characterization must also be made of the workload that the tasks place on the operators. The following steps of the workload analysis are discussed below:

- determine the workload components pertinent to the application,
- develop or adopt workload component rating scales,
- write descriptions of the demands placed on the operators by the tasks, and
- compare the descriptions of the task demands with the workload rating scales to produce workload estimates for each workload component for each task.

Workload, as the term is used in this research, is defined as the total attentional demand placed on the operators as they perform the mission tasks. Consistent with Wickens' theory of human information processing, human attention is viewed as a multidimensional construct of limited availability (Wickens, 1984). This research methodology recognizes different components of attention (e.g., cognitive, psychomotor, and sensory). Thus, workload is the demand on each of these components imposed by all the tasks an operator is currently performing. The methodology further assumes that each of these components is a limited resource that, when expended, will result in degraded task performance or task shedding. The TOSS software can model up to six workload components. The exact decomposition of the components of work-load is flexible in the program. For instance, TOSS can be used to model a theory of attention that identifies only two components, such as verbal attention and spatial attention.

Szabo and Bierbaum (1986) identified five workload components in the analysis of the AH-64 helicopter: cognitive, psychomotor, visual, auditory, and kinesthetic. The cognitive component referred to the attentional demand of information processing that the task required. The psychomotor component referred to the attentional demand required to make coordinated physical responses. The three sensory components referred to the attentional demand of the task-relevant visual, auditory, and kinesthetic processing. Later, Bierbaum et al. (1989) identified one additional component that was relevant to the analysis of the UH-60 helicopter. They identified two visual components: visual-unaided and visual-aided. The visual-aided component was used to describe the attentional demand of the visual processing using night vision goggles (NVG).

The workload analysis requires a workload rating scale for each workload component. The rating scales are used to assign a quantitative value to the amount of attentional demand in each component for each task. The scales should be comprehensive so that the full range of attentional demand is represented. At a minimum, the scales should establish a rank order among the levels of attentional demand; if possible, data should be collected to produce equal-interval scales. Examples of ordinal and interval cognitive workload rating scales are provided in Table 2. Appendix A contains a complete set of interval workload scales taken from a report by Bierbaum et al. (1989). Ordinal scales can be found in a report by Szabo and Bierbaum (1986).

Table 2

Ordinal and Interval Cognitive Workload Rating Scales

Scale Value	Cognitive Anchors
	Ordinal
1	Automatic (Simple Association)
2	Sign/Signal Recognition
3	Alternative Selection
4	Encoding/Decoding, Recall
5	Evaluation/Judgment (Consider Single Aspect)
6	Evaluation/Judgment (Consider Several Aspects)
7	Estimation, Calculation, Conversion
	Interval
1.0	Automatic (Simple Association)
1.2	Alternative Selection
3.7	Sign/Signal Recognition
4.6	Evaluation/Judgment (Consider Single Aspect)
5.3	Encoding/Decoding, Recall
6.8	Evaluation/Judgment (Consider Several Aspects)
7.0	Estimation, Calculation, Conversion

Workload rating scales are developed by constructing verbal anchors that represent different levels of workload for each of the workload components. In the case of ordinal scales, the verbal anchors are ordered by the analysts to represent increasing workload and are assigned a corresponding number from 1 to the number of verbal anchors (see top of Table 2). Interval scales can be constructed using any number of psychometric scaling methods such as pair comparison or magnitude estimation (e.g., Engen, 1971).

Bierbaum et al. (1989) used a pair comparison survey methodology to develop the set of scales shown in Appendix A. Using this method, UH-60 instructor pilots were presented with all possible pairs of the verbal anchors. For each pair, they were required to indicate the verbal anchor with higher workload. These data were used to weight and order the verbal anchors on an equal-interval scale. Refer to the bottom of Table 2 for an example of an interval workload rating scale.

The numerical estimates of workload for the individual tasks are generated using the rating scales. First, descriptions of the attentional demand of each task are written for each workload component. Often the performance of observable tasks requires several components. For example, consider the task of setting a switch in the cockpit. First, cognitive attention is required to decide that a new switch position is necessary. Next, psychomotor attention is expended to move the switch. Finally, visual attention may be required to ensure that the switch is placed in the correct position. Examples of these descriptions can be found in columns 5, 6, and 7 of the Function Analysis Worksheet shown in Table 1. Second, the verbal descriptions of the task workload are compared with the verbal anchors defining the rating scales. The purpose of comparing the verbal descriptions with the verbal anchors is to identify the verbal anchor that best represents the verbal description. The rating scale value associated with the best verbal anchor is assigned to represent the level of workload for that particular component of the task. These ratings are placed below the descriptions in columns 5, 6, and 7 of the Function Analysis Worksheet. Although one analyst may determine the workload rating, it is preferred that at least two analysts discuss the matches and reach a consensus on the rating for each workload component of each task. Subsequently, SMEs can review the consensual ratings.

The methodology allows for further categorization of the workload in each component. For example, psychomotor workload can be categorized by the portion of the body used to perform the task (e.g., left hand, right hand). In a similar manner, visual workload can be categorized by the location of the visual information being processed (e.g., internal or external to the cockpit). The TOSS software retains these categories as workload component specifiers and allows the analyst to define the specifiers that conflict with one another (e.g., two tasks that require the use of the left hand). TOSS uses this information during model execution to indicate that component specifier conflicts have occurred.

The workload analysis produces information describing the workload imposed by each of the tasks identified during the task analysis. TOSS provides data base management of the information gained during the workload analysis. TOSS maintains lists of the workload components used in the model and a list of the workload and workload component specifiers associated with each component of each task. These lists can be created, updated, and printed using the software.

Prior to the full simulation of the operators' actions during the mission, the information about when the tasks will be performed needs to be developed. The process that the TAWL methodology uses to specify the scheduling of tasks during mission simulation is described in the section that follows.

Model Construction

The second stage of the TAWL methodology is the model construction. After the mission is decomposed to identify the tasks associated with the performance of the mission and estimates are made of the workload associated with each task, rules are developed to specify how the tasks are synthesized during the simulation to form functions and segments. Thus, the analyst must describe how the tasks are combined to form functions and how functions are combined to form segments during the model construction stage.

Function Decision Rules

Function decision rules specify the scheduling of tasks within a function. The function decision rules are developed in a two-step process. First, Function Summary Worksheets are developed. Second, function decision rules are developed using the Function Summary Worksheets.

For each of the unique functions identified during the decomposition process, a Function Summary Worksheet is developed. An example Function Summary Worksheet is shown in Table 3. The Function Summary Worksheet describes three types of information. First, the crewmember performing each task is indicated by placing the task name and number in a column under the appropriate crewmember's title. Second, the approximate temporal relationships among the tasks are portrayed by the position of the tasks on the worksheet: tasks placed higher on the page occur prior to tasks placed lower on the page; concurrent tasks are placed side by side. Third, the task category is indicated by placing it into one of the four columns below each crewmember's title.

Table 3

Function Summary Worksheet

FUNCTION 081 Load Weapons (Rearming)

PILOT				GUNNER			
DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	CONTINUOUS RANDOM	DISCRETE FIXED	DISCRETE .RANDOM	CONTINUOUS FIXED	CONTINUOUS RANDOM
Check MASTER ARM Switch (396)				Set PLT/GND ORIDE Switch (461)			
Set TAILWHEEL Switch (573)							
Set Park Brake (455)							
Set Brake Lever (658)							
				Check Pylon Safety Pins (481)			
				Check Grounding Cables (283)			
					Monitor Weapons Loading (641)		
				Check Grounding Cables (283)			
				Check Pylon Safety Pins (481)			

For the purposes of the TAWL methodology, tasks are categorized using two dimensions: Discrete vs Continuous and Fixed vs Random. The Discrete vs Continuous distinction has been described above. The Fixed vs Random dimension relates to the time at which the task is performed during the mission. Fixed tasks are tasks that are performed at a predetermined time; that is, the performance of the task is fixed in relation to other tasks performed during the mission. Random tasks are tasks for which the time of performance is difficult or impossible to determine *a priori*. The performance of these tasks holds no fixed relation to other tasks during the mission, and the time at which random tasks are performed may be affected by any number of factors (e.g., individual differences, current workload).

When all four possible combinations of the two task dimensions are combined, the following definitions are produced:

- Discrete Fixed - A task that is performed at a predetermined time in the function and whose magnitude of performance does not determine the magnitude of the resulting system change (e.g., setting the park brake).

- Discrete Random - A task that is performed at an undetermined time in the function and whose magnitude of performance does not determine the magnitude of the resulting system change (e.g., check flight instruments, check obstacle clearance).

- Continuous Fixed - A task that is performed at a predetermined time in the function and whose magnitude of performance determines the magnitude of the system response; the resulting state of the system in turn, determines the magnitude of the subsequent performance of the task (e.g., perform visual search, track target).

- Continuous Random - A task that is performed at an undetermined time in the function and whose magnitude of performance determines the magnitude of the system response; the resulting state of the system in turn, determines the magnitude of the subsequent performance of the task (e.g., control altitude, control drift, control attitude, control heading).

The Function Decision Rules Worksheets are developed using the Function Summary Worksheets. An example of a Function Decision Rules Worksheet is shown in Table 4. Function Decision Rules Worksheets specify

Table 4

Function Decision Rules Worksheet

FUNCTION 081 Load Weapons (Rearming)

PILOT				GUNNER			
DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	CONTINUOUS RANDOM	DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	CONTINUOUS RANDOM
Program in sequence, the following tasks (include a .5-second delay between tasks): Task 396 for 1 second Task 573 for 1 second Task 455 for 2 seconds Task 658 for 1 second Standby 942.5 seconds				Program Task 461 for 1 second Standby 5.5 seconds When Task 658 ends, program, in sequence, the following tasks (include a .5- Task 283 for 18 seconds Continued...	Continued...		

the exact sequence and time for the performance of the tasks during the function. The decision rules on the worksheets specify the start time, duration and crewmember performing each of the discrete fixed and continuous fixed tasks. The TOSS software models both the discrete random and the continuous random tasks as sets, the decision rules identify each task in the set, establish the duration of the tasks, designate the crewmember performing the tasks, and specify the start and duration of the period during the function that the tasks may occur. For the discrete random task set, the decision rules also specify the number of times that a task from the set is expected to be performed and whether performing a discrete random task from the set interrupts the performance of the continuous random task set.

TOSS provides data base management of the function decision rules developed during the construction of the model. TOSS maintains lists of the scheduling information for all four types of tasks that occur in function decision rules. The lists can be created, updated, and printed using the software. The Function Decision Rules Worksheets are then used in the development of the segment decision rules.

Segment Decision Rules

After the function decision rules are completed, the segment decision rules are developed. Segment decision rules specify the scheduling of functions within a segment. The segment decision rules are developed in a two-step process. First, Segment Summary Worksheets are completed. Second, segment decision rules are developed using the Segment Summary Worksheets.

A Segment Summary Worksheet is developed for each unique segment identified during the decomposition process. An example Segment Summary Worksheet is shown in Table 5. The Segment Summary Worksheet describes three types of information. First, the crewmember performing each function is indicated by placing the name of the function in a column under the crewmember's title. If more than one crewmember performs tasks in the function, the name of the function is entered for each crewmember performing tasks in the function. Second, the approximate temporal relationships among the functions are portrayed by the position of the functions on the worksheet: functions placed higher on the page occur prior to functions placed lower on the page; concurrent functions are placed side by side. Third, the function category is indicated by placing it into one of the three columns below each crewmember's title. The methodology recognizes the following three categories of functions:

Table 5

Segment Summary Worksheet

PHASE 4 Target Servicing SEGMENT 44 Engagement, Gun (Gunner, Normal)

PILOT			GUNNER		
DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED
	Monitor Threat (084)	Hover Unmasked (076)			Track Target (IHADSS/ Gunner) (150)
		Monitor Audio (083)	Fire Weapon, Gun *(Gunner)* (063)		Monitor Audio (083)
Mask Aircraft (082)	Initiate Cockpit Communication (Pilot) (079)			Initiate Cockpit Communication (Gunner) (078)	
	Initiate Cockpit Communication (Gunner) (078)			Initiate Cockpit Communication (Pilot) (079)	

- Discrete Fixed - A function that is performed at a predetermined time in the segment and whose start and end points are defined by its discrete fixed tasks (e.g., mask aircraft, acquire target).

- Discrete Random - A function that is performed at an undetermined time in the segment and whose start and end points are defined by its discrete fixed tasks (e.g., monitor threat, cockpit communications).

- Continuous Fixed - A function that is performed at a predetermined time in the segment and whose start and end points are defined by its continuous fixed tasks. Thus, mission requirements and conditions determine their start and end points (e.g., hover unmasked, perform navigation).

The Segment Decision Rules Worksheets are developed using the Segment Summary Worksheets. An example of a Segment Decision Rules Worksheet is shown in Table 6. Segment Decision Rules Worksheets specify the exact sequence and time for the performance of the functions during the segment. The worksheets specify the start time and duration for each of the discrete fixed and continuous fixed functions. During the execution of a segment, an operator may halt the performance of one function, perform another function to completion, then continue to perform the first function from the point of interruption. This process is referred to as an interrupt. The segment decision rules identify the functions that interrupt each of the discrete fixed and continuous fixed functions.

The Segment Decision Rules Worksheets specify a start and finish time that define the time window in which each of the discrete random functions occur. This active period can span the entire segment or only part of it. The worksheets also specify the number of times that each discrete random function is expected to occur during the active period. For example, the discrete function of checking engine instruments is performed randomly by the pilot approximately once every 180 seconds during contour flight. In a segment consisting of takeoff (300 seconds), contour flight (600 seconds), and landing (300 seconds), the active period for the random performance would start at 300 seconds and finish at 900 seconds into the segment, and the number of times that the function would be expected to be performed is 3. During takeoff and landing, the same function is modeled as a discrete function.

Finally, the Segment Decision Rules Worksheets specify the pairs of functions that may not be executed concurrently. These functions are referred to as function clash pairs. If two functions clash, the execution of the second function is delayed until the first function is finished. For example, a pilot cannot communicate with the copilot and the tower at the same time. Thus, the

Table 6

Segment Decision Rules Worksheet

PHASE 4 **Target Servicing** **SEGMENT 44** **Engagement, Gun (Gunner, Normal)**

PILOT			GUNNER		
DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED	DISCRETE FIXED	DISCRETE RANDOM	CONTINUOUS FIXED
Start Function 082 when Function 076 ends. Function 082 lasts 7.5 seconds.	2 times, randomly select Function 084 to interrupt Function 076 for 3.5 seconds. Randomly select (.50) Function 078 or 079 to occur concurrently with Function 082. Functions 078 and 079 last 7 seconds each.	Start Segment 44 with Function 076. Function 076 lasts until Function 063 ends. Start Function 083 concurrently with Function 076. Function 083 lasts throughout the segment.	Start Function 063 4.5 seconds after Function 150 begins. Function 063 lasts 9.5 seconds.	Randomly select (.50) Function 078 or 079 to occur concurrently with Function 082. Functions 078 and 079 last 7 seconds each.	Start Segment 44 with Function 150. Function 150 lasts until Function 063 ends. Start Function 083 concurrently with Function 150. Function 083 lasts throughout the segment.

functions "perform cockpit communications" and "perform external communications" are a clash pair.

TOSS provides data base management of the segment decision rules developed during the construction of the model. Lists of the scheduling information for all three types of functions that occur in segment decision rules are maintained by the system. TOSS also maintains a list of function clash pairs. Two functions that clash in any segment, clash in every segment; therefore, the function clash pairs are specified only once for the entire model. The lists can be created, updated, and printed using the software.

The development of the function and segment decision rules completes the construction of the model data base. The following section describes the execution of a model developed using the TAWL methodology.

Model Execution

The third stage in the Task Analysis/Workload methodology is the model execution. The specification of segments, functions, tasks, function decision rules, segment decision rules, and function clash pairs enables TOSS to simulate the crewmember tasks during each segment of the mission. The following paragraphs describe the randomization, workload summation, and overload computation procedure used in executing the model. Also discussed are the results of model execution.

Randomization

During model construction, some of the tasks and functions are categorized as random. During model execution, TOSS randomizes two different aspects of the random tasks and functions. First, the start times of the random tasks and functions are generated randomly. Second, the number of times that the random tasks and functions are scheduled to occur is randomized. The number of times that the tasks and functions are scheduled is based on the number of times that they are expected to occur, but the number of times they are performed during simulation varies. Random tasks and functions may not be performed at all or they may be performed as many as 1.5 times the expected frequency.

Workload Summation

TOSS estimates the crewmember workload imposed by concurrent tasks by summing the workload ratings for individual workload components. For instance, ratings of visual workload for all tasks being performed concurrently

are summed. It is important to emphasize that TOSS does not presently sum workload ratings across workload components.

Overload Threshold

The TAWL methodology defines operator overload as the level of workload at which workload begins to degrade operator performance. In TOSS, the user can establish any workload level as an overload threshold. In the model developed for the attack helicopter analysis, the overload threshold was set at 8 because the verbal anchor representing the highest possible workload was assigned a workload magnitude of 7 on the workload rating scales. Therefore, workload that sums to 8 or more is considered to be an overload. The exact overload threshold has yet to be identified through experimentation.

The overload threshold is used to compute four metrics of overload for each execution of the model: component overloads, overload conditions, overload density, and subsystem overloads. Component overloads are the number of half-second periods that a workload component exceeds the overload threshold. Overload conditions are the number of variable-length periods when one or more component overload occurs. A new overload condition is counted whenever the tasks contributing to a component overload change. Overload density is the percentage of time that an overload condition occurs within a mission segment. Finally, subsystem overloads are the number of times that a subsystem is associated with a component overload.

Execution Results

The segment level of analysis is the highest level directly simulated by TOSS. The software executes one segment at a time. The methodology assumes that phases and missions can be adequately simulated by the sequential analysis of their constituent segments. The execution of one segment of a workload prediction model produces the following data:

- a time line of the segment annotated with the tasks and functions that occur during the simulation,
- estimates of each crewmember's workload for each half-second of the segment,
- a time line indication of periods that have component overloads,
- a time line indication of the number of overload conditions that occur during the segment,
- a time line indication of the subsystems associated with all the tasks being performed during each overload condition,
- a time line indication of periods in which concurrent tasks have conflicting workload specifiers,

- a summary of the component overloads for each crewmember during the segment,
- a summary of the overload conditions for each crewmember during the segment,
- a summary of the percentage of time that each crewmember is in an overload condition during the segment,
- a summary of the subsystem overloads that occur during the segment, and
- a summary of the number of times that all discrete random functions occur during the segment.

Analysts or SMEs may review the model execution results to determine if the decision rules produce a realistic simulation of the mission. Often, the original decision rules need to be revised to generate a more realistic simulation. The development of a workload prediction model is complete when the model produces a realistic simulation of all mission tasks.

Summary

The Task Analysis/Workload methodology produces a model that predicts operator workload for new or existing systems. The method relies on a comprehensive task analysis of a system's typical mission to simulate each operator's actions. The workload analysis produces estimates, by component, of the attentional demands of each task.

The methodology uses decision rules to specify the sequence of events in the mission simulation. During simulation, the workload estimates for the tasks that the operator is performing currently are summed separately for each component. Thus, the methodology represents each operator's workload for each half second of the mission, with a separate value for each of the workload components. The methodology identifies the component overloads, overload conditions, overload density, and the subsystems associated with overload.

The step-by-step instructions for using TOSS in support of the Task Analysis/Workload methodology are provided in the second part of the User's Guide.

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Part II

TAWL Operator Simulation System (TOSS)

Version 3.0

OVERVIEW

The TOSS software was developed to support the Task Analysis/ Workload (TAWL) methodology. TOSS performs all of the data base management and model execution functions needed to use the methodology. The task data and the decision rules are entered using the data entry routines of the software. The conditions specified in the decision rules are implemented to build functions from tasks and segments from functions. In doing so, TOSS simulates the behavior of the crewmembers during the segment and identifies all tasks performed by each crewmember during each half-second of the segment. Totals are maintained for each workload component to identify the conditions and density of operator overload for each segment.

TOSS can be used to manage more than one workload prediction model. This allows for the comparison and analysis of several models at once. A user can create a data base (enter, update, and print data), execute a model, or change models from within the software. The program is menu-driven with on-screen directions.

TOSS can produce the following five different forms of output:

- No Output File,
- Simulation Listing,
- Abbreviated Simulation Listing,
- Numerical Data Files, and
- Task Listing.

The output options are described in the EXECUTE THE MODEL section on page 56.

SYSTEM REQUIREMENTS

To use the TOSS software, the following are required or recommended:

- an IBM compatible computer and a keyboard,
- 640 Kb of memory,
- DOS operating system v2.0 or greater,
- a hard disk drive (recommended), and
- a printer (recommended).

INSTALLING TOSS

To install TOSS on your hard drive, perform the following steps:

1. Place the TOSS floppy diskette in drive A:.

2. Type "A:INSTALL" and press the <ENTER> key.

   This command will execute the INSTALL.BAT batch file, which creates a \TOSS subdirectory on the current hard drive and copies the TOSS program files into that subdirectory. If the subdirectory \TOSS already exists on the hard drive, the batch file will copy the TOSS program files into that subdirectory. To install TOSS on a subdirectory other than \TOSS, give the subdirectory name as a parameter to the install command (e.g., "A:INSTALL MODEL"). Installation of TOSS should only be required once.

GETTING STARTED

To use TOSS for the development of a workload prediction model, execute the following steps:

1. Type the DOS command "CD TOSS" and press the <ENTER> key.

   This command will make the TOSS subdirectory the current directory. To avoid issuing this command every time you run TOSS, place the TOSS subdirectory on the DOS path as specified in the DOS manual.

2. Type "TOSS" at the DOS command line and press the <ENTER> key.

   This command will execute TOSS and will present a brief introductory screen and a graphic display of a helicopter (TOSS was originally developed for rotary wing aircraft).

3. Type in the disk drive designation.

   TOSS maintains workload models as sets of data files. Normally the data files are kept on the same disk drive as the TOSS software, but you may specify any disk drive (A-E). If the data files are on hard disk drive C, respond to the **ENTER DRIVE A-E:** prompt by pressing the <C> key without pressing the <ENTER> key. TOSS will present a graphic representation of the directory structure on the C disk.

4. Advance the cursor to the desired directory using the arrow keys.

   TOSS can work with many different workload models on the same computer system. The computer files that represent different models are maintained in separate disk subdirectories. You can use the Directory Utility to select any subdirectory on the disk drive designated in Step 3. If the model data files are already loaded on the computer, use the arrow keys to move the cursor to the subdirectory that contains the model. The display will scroll, if necessary.

   To create a new model subdirectory, advance the cursor using the arrow keys to the TOSS subdirectory. Press the <A> key for Add Directory, enter the name of the new model's subdirectory, and press the <ENTER> key. You must confirm your request at the bottom of the screen. If the subdirectory does not already exist, the Directory Utility will create it as a subdirectory to TOSS. To indicate that the new subdirectory will contain the model's data files, advance the cursor using the arrow keys to that subdirectory.

   The Directory Utility can perform other operations. The <L> or log onto drive command allows you to work with a model stored on a different disk drive than the one you specified in Step 3. The <M> or memory command shows how much disk space is available on the specified drive. The <D> or delete command allows you to delete an empty directory. Finally, the <R> or rename command allows you to rename any directory on the disk as long as the new name is not already in use.

   When all Directory Utility commands have been completed, exit by pressing the <ESC> key.

5. Press the <ENTER> key.

   The <ENTER> key tells TOSS that the model is maintained in the subdirectory that you selected in Step 4. If the model already exists, the Main Menu will be displayed as shown below.

Main Menu

1. System Parameters
2. Task/Workload Analysis
3. Decision Rules
4. Execute the Model
5. File Handling
6. Move to a Different Model

ESC: Leave Menu

If no data files are found in the specified subdirectory, **DO YOU WISH TO CREATE A NEW SETUP FILE (Y/N)** will be displayed. A <N> response will return you to the **ENTER DRIVE A-E:** prompt described in Step 3. To create a new setup file, press the <Y> key and **MODEL NAME:** will be displayed. Enter the new model name and press <ENTER>. The Main Menu will now be displayed so that you can create, edit, and execute the model. Table 7 presents the Main Menu selections and descriptions of the second level subordinate menu that will be displayed when the Main Menu option is selected.

Table 7

Main Menu Selections and Descriptions of the Subordinate Menus

Main Menu (First Level)	Subordinate Menus (Second Level)
1. System Parameters	1. Model Name (model name for printouts) 2. Maximum Segments (number of segments in the model) 3. Maximum Functions (number of functions in the model) 4. Crew Configuration (crew identification) 5. Subsystem Codes (abbreviations for aircraft subsystems) 6. Workload Components (composite list of workload components)
2. Task/Workload Analysis	1. Task Names (entry routine) 2. Function Names (entry routine) 3. Segment Names (entry routine) 4. Task Workloads (entry routine) 5. Task Subsystems (entry routine)
3. Decision Rules	1. Function Decision Rules (entry routine) 2. Segment Decision Rules (entry routine) 3. Function Clash Pairs (entry routine)
4. Execute the Model	(executes the decision rules)
5. File Handling	1. Select Files (allows user to select new data files) 2. Print Files (allows user to print data files) 3. Directory Utility (limited directory utility)
6. Move to a Different Model	(choose a different model)

There are up to three levels of menus in the TOSS software: the first level menu and two lower levels of subordinate menus. The use of each item on all three menu levels is described in the following sections of the user's guide. The description of each menu item is formatted differently to indicate its level. Figure 2 displays the different formats for the three levels. For all menus in the software, the items are executed by pressing a single number key on the computer keyboard. For each item description, the number that is associated with the name of the item corresponds to the computer key that executes that item. The first level menu items are described in separate sections that start on a new page. The second level menu items are indicated within the first level sections by a diamond shape around the number of the corresponding computer key. The third level menu items are indicated within the second level sections by an oval shape around the number of the corresponding computer key.

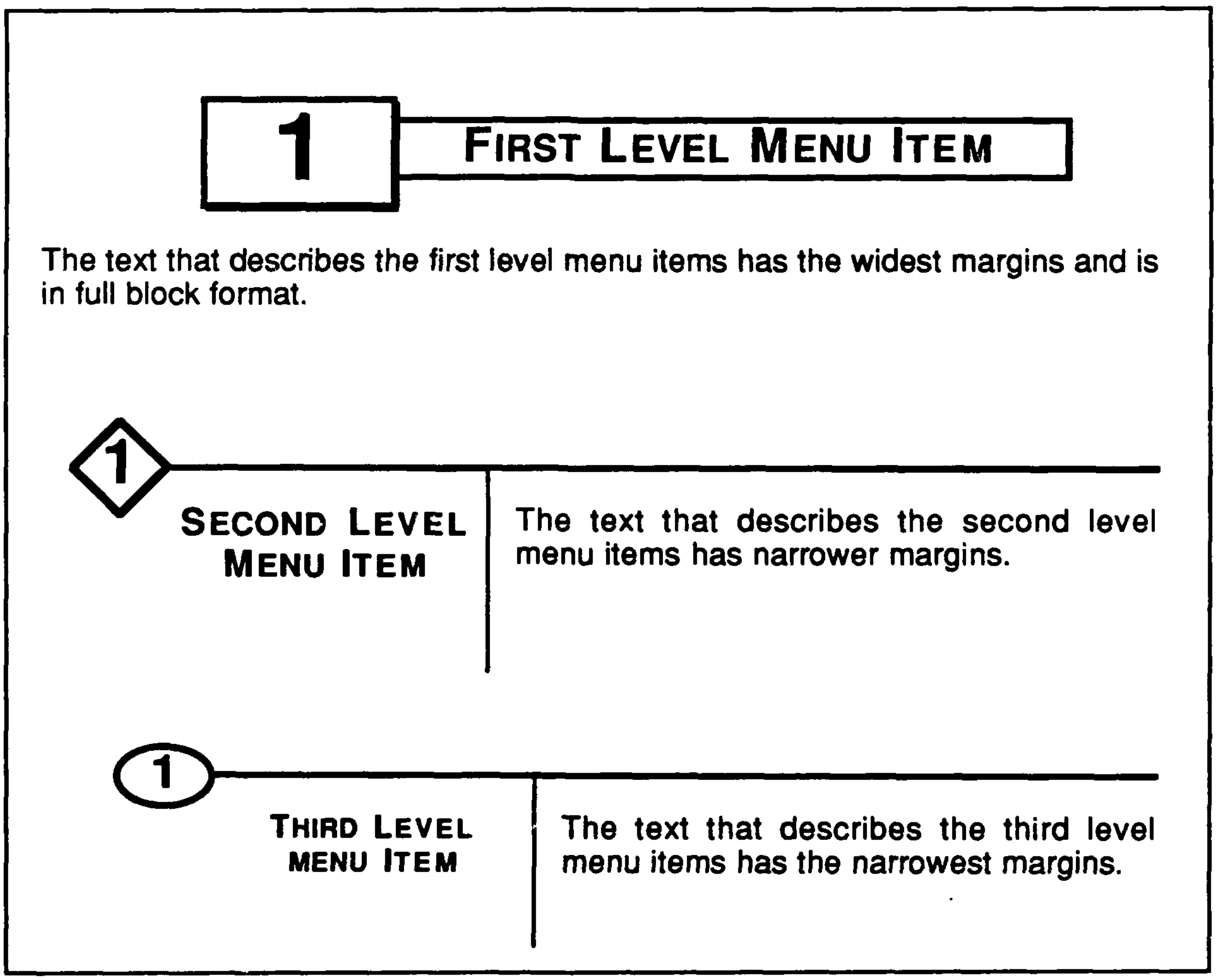

Figure 2. Text format of the descriptions of three levels of menu items in TOSS.

1 SYSTEM PARAMETERS

TOSS uses a number of parameters to define the basic characteristics of a workload prediction model. Those parameters are entered or modified in TOSS using the System Parameters Menu.

Press the <1> key to execute the System Parameters routine on the Main Menu. This will display the following System Parameters Menu:

1: MODEL NAME
2: MAXIMUM SEGMENTS
3: MAXIMUM FUNCTIONS
4: CREW CONFIGURATION
5: SUBSYSTEM CODES
6: WORKLOAD COMPONENTS
ESC: LEAVE MENU

1 MODEL NAME

Press the <1> key to change the name of the model previously used to establish the model.

The current model name will be displayed at the top of the screen.

Enter the new name of the model (up to 66 alpha-numeric characters) at the **NEW MODEL NAME:** prompt and press the <ENTER> key to return to the System Parameters Menu.

If you do not wish to change the current name, press the <ENTER> key before pressing any other key.

The new model name will be displayed at the top of all subsequent menus in the program.

2

MAXIMUM SEGMENTS

Press the <2> key to enter or edit the number of segments in the model.

Enter the number of segments and press the <ENTER> key to return to the System Parameters Menu. If the number of segments is correct, press the <ENTER> key.

To edit, use the <BACKSPACE> key.

3

MAXIMUM FUNCTIONS

Press the <3> key to enter or edit the number of functions in the model.

Enter the number of functions and press the <ENTER> key to return to the System Parameters Menu. If the number of functions is correct, press the <ENTER> key.

To edit, use the <BACKSPACE> key.

4

CREW CONFIGURATION

Press the <4> key to enter or edit the names of up to four crewmembers in the model.

The Crew Configuration Menu has an option for each crewmember that is currently defined in the model. If less than four crewmembers are defined, an **ADD CREWMEMBER** option will follow the last defined crewmember.

To add a new crewmember, press the number key that appears beside the **ADD CREWMEMBER** option. **ENTER CREWMEMBER CODE:** will be displayed. Press the single letter (A-Z) key that will be used to designate the crewmember in the model followed by the <ENTER> key.

ENTER CREWMEMBER NAME: will be displayed. Type the crewmember's name (up to 12 alphanumeric characters, no spaces) and press the <ENTER> key to return to the Crew Configuration Menu.

CREW CONFIGURATION (CONTINUED)

Continue this process until all crewmembers are entered.

To edit or delete an entry already on the menu, press the key for the number beside the crewmember. **DO YOU WISH TO DELETE THE CREWMEMBER? (Y/N)** will be displayed. If you do, press the <Y> key. The crewmember will be deleted and you will return to the Crew Configuration Menu. Otherwise, press the <N> key to change any of the information associated with the crewmember.

To leave any entry unchanged, press the <ENTER> key before pressing any other key.

To edit the crewmember name, use the <BACKSPACE> key.

When all adding, editing, and deleting are completed, press the <ESC> key to return to the System Parameters Menu.

5

SUBSYSTEM CODES

Press the <5> key to establish or edit up to seven subsystem group codes.

The Subsystem Code Menu has an option for each subsystem group that is currently defined in the model. If less than seven subsystem groups are defined, an **ADD SUBSYSTEM CODE** option will follow the last subsystem group.

To add a new group of subsystems, press the number key that appears beside the **ADD SUBSYSTEM CODE** option. **ENTER SUBSYSTEM GROUP CODE (A-Z):** will be displayed. Enter the single letter designator for the subsystem group followed by the <ENTER> key.

ENTER SUBSYSTEM GROUP NAME: will be displayed. Enter the name (up to 30 alphanumeric characters) and press the <ENTER> key. **ENTER SUBSYSTEM CODE #1:** will be displayed.

SUBSYSTEM CODES (CONTINUED)

Enter up to ten subsystem codes. Type a subsystem code (up to 3 letters) and press the <ENTER> key. You will be prompted for the name of the subsystem. Type the subsystem name (up to 30 alphanumeric characters) and press the <ENTER> key.

Continue this process until all subsystem codes and names have been entered for the subsystem group. Press the <ESC> key to return to the Subsystem Codes Menu.

The new subsystem group will now appear on the Subsystem Codes Menu. Continue this process until all subsystem groups and codes have been entered.

To edit or delete an entry already on the menu, press the key for the number beside the subsystem group. **DO YOU WISH TO DELETE SUBSYSTEM CODES? (Y/N)** will be displayed. If you do, press the <Y> key. The subsystem codes will be deleted and you will return to the Subsystem Codes Menu. Otherwise, press the <N> key to change the codes and names for the subsystem group or the individual subsystems in the group. To leave any entry unchanged, press the <ENTER> key. Press the <ESC> key to return to the Subsystem Codes Menu.

When all adding, editing, and deleting of subsystem codes are completed, press the <ESC> key to return to the System Parameters Menu.

6

WORKLOAD COMPONENTS

Press the <6> key to enter or edit up to six workload components.

The Workload Components Menu has an option for each workload component that is currently defined in the model. If less than six workload components are defined, an **ADD COMPONENT** option will follow the last defined component.

To add a new workload component, press the number key that appears beside the **ADD COMPONENT** option. **ENTER COMPONENT ABBREVIATION:** will be displayed. Type the component abbreviation (up to 3 letters) and press the <ENTER> key.

WORKLOAD COMPONENTS (CONTINUED)

ENTER COMPONENT NAME: will be displayed. Type the component name (up to 12 alphanumeric characters) and press the <ENTER> key.

ENTER OVERLOAD MINIMUM: will be displayed. The default overload minimum is 8.0. To change the overload threshold, type the desired number and press the <ENTER> key. Press the <ENTER> key to leave the overload threshold unchanged.

ENTER SPECIFIER: will be displayed. If there are no specifiers, press the <ENTER> key to return to the Workload Component Menu. To add further categorization to the workload component enter single letter specifier and press the <ENTER> key (e.g., an E and I for External and Internal visual component).

To delete a specifier entered in error, reenter the letter and press the <ENTER> key.

When all specifiers are entered, press the <ENTER> key. SPECIFIER CONFLICT PAIRS: will be displayed. Identify the component specifiers that would conflict with each other if they occurred at the same time (e.g., two tasks requiring the use of the right hand at the same time).

To enter the specifier conflict pairs, press the <INS> key and type the first specifier and press the <ENTER> key. Then type the second specifier and press the <ENTER> key.

To delete a conflict pair, highlight the pair using the arrow keys and press the <DEL> key.

Continue this process until all conflicting pairs have been entered, then press the <ENTER> key to return to the Workload Components Menu.

Continue this process until all workload components are entered.

WORKLOAD COMPONENTS (CONTINUED)

To edit or delete an entry already on the menu, press the key for the number beside the component. **DO YOU WISH TO DELETE COMPONENT? (Y/N)** will be displayed. If you do, press the <Y> key. The component will be deleted and you will return to the Workload Components Menu. Otherwise, press the <N> key to change any of the information associated with the workload component.

To leave any entry unchanged, press the <ENTER> key.

When all the workload components are added, press the <ESC> key to return to the System Parameters Menu.

Entering the workload components completes the specification of the system parameters. Press the <ESC> key to return to the Main Menu.

2 TASK/WORKLOAD ANALYSIS

After the mission task analysis is completed, enter the data obtained from the analysis.

Press the <2> key on the Main Menu to execute the Task/Workload Analysis routine. This will display the following Task/Workload Menu:

1: TASK NAMES
2: FUNCTION NAMES
3: SEGMENT NAMES
4: TASK WORKLOADS
5: TASK SUBSYSTEMS
ESC: LEAVE MENU

1

TASK NAMES

Press the <1> key to enter or edit the names of the tasks in the model.

The screen will display the first page of task names currently defined in the model and ask for a task number.

To add a new task name, enter the task number and press the <ENTER> key. The screen will display the task number and will prompt for the name of the task. Enter the task name (up to 66 alphanumeric characters) and press the <ENTER> key.

You will return to the screen asking for the task number. The new task number and name will be displayed in the task list. Continue entering the task numbers and names until all tasks in the model are entered.

To change or delete an existing task name, enter the task number beside the existing task and press <ENTER>. An update menu will be displayed to update or delete the task. Press the <1> key and **ENTER NEW TASK NAME:** will be displayed. Enter the new name and press <ENTER> to return to the task list. Press the <2> key to delete the task and return to the task list.

TASK NAMES (CONTINUED)

Press the <ESC> key to return to the Task/Workload Menu.

2

FUNCTION NAMES

Press the <2> key to enter or edit the names of the functions in the model. The procedure for entering function names is the same as the procedure for entering task names. Refer to the Task Names section above if further instructions are required.

Press the <ESC> key to return to the Task/Workload Menu.

3

SEGMENT NAMES

Press the <3> key to enter or edit the names of the segments in the model. The procedure for entering the segment names is the same as the procedure for entering the task names. Refer to the Task Names section above if further instructions are required.

Press the <ESC> key to return to the Task/Workload Menu.

4

TASK WORKLOADS

Press the <4> key to enter or edit the component workloads associated with each task.

ENTER TASK NUMBER: will be displayed.

To add a new set of workloads for a task, enter the task number and press the <ENTER> key. The screen will display the task number and prompt for each component workload (i.e., Audio, Visual, Cognitive, Kinesthetic, Psychomotor) defined in the model. Enter the estimate of workload for each component.

(Note: If the screen only displays the workload number and not the prompts for the workload components, return to the System Parameters under the Main Menu and define the workload components.)

TASK WORKLOADS (CONTINUED)

If a specifier is indicated for a component in the Workload Component section above, **ENTER SPECIFIER:** will be displayed next to the component prompt. Type the task specifier and press <ENTER>.

After entering the workload for all components, press the <ESC> key to return to the screen asking for a new task number.

The task and the new workloads will be displayed on the screen.

Continue entering the workload for all tasks.

To change or delete an existing set of task workloads, follow the procedures described under Task Names.

Press the <ESC> key to return to the Task/Workload Menu.

5 TASK SUBSYSTEMS

Press the <5> key to enter or select the subsystem associated with each task.

ENTER TASK NUMBER: will be displayed.

To add new subsystems for a task, enter the task number for the subsystem and press the <ENTER> key.

Space is available for three subsystem codes for each task. Enter each subsystem code associated with the task and press the <ENTER> key. Press the <ESC> key when all the task subsystems are entered.

You will return to the screen asking for a new task number. Each of the subsystems entered so far will be displayed with their task number.

Continue entering the subsystems for all tasks in the model.

To change or delete existing task subsystems, follow the procedures described under Task Names.

Press the <ESC> key to return to the Task/Workload Menu.

TASK/ WORKLOAD ANALYSIS (CONTINUED)

When the entry of the data obtained from the task analysis is completed, press the <ESC> key to return to the Main Menu.

3 DECISION RULES

After the Task/Workload Analysis data entry is completed, enter the decision rules that describe how the tasks and functions will be combined during the execution of the model. It is helpful to use the Print Files routine under the File Handling Menu to print a list of the function and segment names and numbers before creating or editing the function decision rules. The order that the tasks or functions are entered into the decision rules does not determine the order that they will be executed. Only the information in the entries (i.e., start and duration) is used to schedule them.

Press the <3> key to execute the Decision Rules routine on the Main Menu. This will display the following Decision Rule Menu:

1: FUNCTION DECISION RULES
2: SEGMENT DECISION RULES
3: FUNCTION CLASH PAIRS
ESC: LEAVE MENU

1 FUNCTION DECISION RULES

Press the <1> key to enter or edit the Function Decision Rules.

The name of the current Function Decision Rule file will be displayed at the top of the screen. At the **ENTER FUNCTION NUMBER:** prompt, enter the number of the function decision rule that you want to enter or edit and press the <ENTER> key. Use the same number that was paired with the function names under the Task/Workload Analysis Menu.

A menu will be displayed with the name of the function and the following options:

1: DISCRETE FIXED TASKS
2: DISCRETE RANDOM TASKS
3: CONTINUOUS RANDOM TASKS
4: CONTINUOUS FIXED TASKS
ESC: LEAVE MENU

Each of these subroutines is described below.

1

Discrete Fixed Tasks

Press the <1> key to enter or edit the discrete fixed tasks in the function.

An edit screen will be displayed with the name and number of the function at the top of the screen followed by the task number, crewmember, start time, and duration of the first discrete fixed task in the decision rule.

If no tasks have been entered, there will be no information beside these prompts. The bottom of this screen will display a short description of the active commands with the cursor to the right of the **PRESS A KEY:** prompt.

Press the <F5> key to add a new entry to the end of the list or to make the first entry of a new decision rule. A blank entry will be displayed and the cursor will move to the **TASK:** prompt. Enter the task number and press the <ENTER> key.

The cursor will move to the **CREW:** prompt. Designate the crewmember (e.g., P, C, G) who performs the task and press the <ENTER> key.

The cursor will move to the **START:** prompt. Enter the start time in seconds since the beginning of the function and press the <ENTER> key.

The cursor will move to the **DURATION:** prompt. Enter the duration of the task in seconds and press the <ENTER> key.

The cursor will be returned to the **PRESS A KEY:** prompt at the bottom of the screen.

If the function has more than 40 tasks, refer to the Split Functions box on page 49.

To edit existing tasks, press the <RIGHT ARROW> and <LEFT ARROW> keys to move through the list of tasks. Press the <RIGHT ARROW> key to move toward the end of the list. Press the <LEFT ARROW> key to move toward the beginning of the list.

DISCRETE FIXED TASKS (CONTINUED)

Press the <F1> key to edit the task, crew, start time, and duration data for the selected task. Press the <ENTER> key if you do not want to change a particular field.

Press the <F9> key to delete the current entry from the list and display the next entry on the screen.

When all entries that describe the discrete fixed tasks are defined and edited, press the <ESC> key to return to the Function Decision Rules Menu.

2

DISCRETE RANDOM TASKS

Press the <2> key to enter or edit the discrete random task set in the function.

An edit screen will be displayed with the name and number of the function at the top of the screen, followed by the prompts for the task numbers, durations, crewmember, start time, finish time, execution times, and interrupt of the set of discrete random tasks. Unlike the Discrete Fixed tasks, which are entered with one task per screen, all Discrete Random tasks for the function are entered on a single screen.

If no tasks have been entered, there will be no information beside these prompts. The bottom of the screen will display a short description of the active commands with the cursor to the right of the **PRESS A KEY:** prompt.

Press the <F1> key to add or change the tasks, durations, crewmembers, start time, finish time, times to occur, and interrupt data fields. The program will display an **ENTER:** prompt below the first task number in the set.

Up to seven task numbers and durations may be entered before moving to the remaining fields on the screen.

If the discrete random task set has less than seven entries, press the <ENTER> key without entering a task number to move to the remaining fields.

DISCRETE RANDOM TASKS (CONTINUED)

Enter the single letter designation for the crewmember performing the tasks at the **CREW:** prompt and press the <ENTER> key.

Enter the time to begin the random set active period at the **START:** prompt and enter the time to end the random set active period at the **FINISH:** prompt. These times define the window in which the task set will be active.

Enter the average number of times that a task from the set is to be performed at the **TIMES:** prompt.

Enter a <Y> or <N> at the **INTERRUPT:** prompt to indicate whether performance of a discrete random task from the set interrupts performance of the continuous random tasks of the function, then press <ENTER>.

To change any entry, type the new information at the **ENTER:** prompt and press the <ENTER> key.

To leave any entry unchanged, press the <ENTER> key.

To delete an existing task and duration from the set, press the <DEL> key at the prompt for the task number.

Press the <F9> key to delete and clear the set from the screen.

When the set of discrete random tasks is completed, press the <ESC> key to return to the Function Decision Rules Menu.

3

CONTINUOUS RANDOM TASKS

Press the <3> key to enter or edit the continuous random tasks in the function.

An edit screen will be displayed with the name and number of the function at the top of the screen, followed by the task numbers, duration, crewmember, start time, and finish time of the set of continuous random tasks in the decision rule.

CONTINUOUS RANDOM TASKS (CONTINUED)

If no tasks have been entered, there will be no information beside these prompts.

Tasks from the continuous random task set are constantly being selected during the active period defined by the start and finish fields. Follow the instructions described for the discrete random tasks above to enter the tasks, duration, crewmember, start time, and finish time.

Press the <F1> key to enter or edit the set and the <F9> key to delete the set.

When all tasks that describe the continuous random task set are entered, press the <ESC> key to return to the Function Decision Rules Menu.

4

CONTINUOUS FIXED TASKS

Press the <4> key to enter or edit the continuous fixed tasks in the function.

An edit screen will be displayed with the name and number of the function at the top of the screen, followed by the task number, crewmember, start time, and duration of the first continuous fixed task in the decision rule.

If no tasks have been entered, there will be no information beside these prompts.

The bottom of this screen displays a short description of the active commands with the cursor to the right of the **PRESS A KEY:** prompt.

Press the <F5> key to add a new entry to the end of the list or to enter the first entry of a new decision rule. The <F5> key displays a blank entry and allows you to enter the task number, crewmember, start time, and duration of the new task.

The <RIGHT ARROW> and <LEFT ARROW> keys move you through the list of task screens. Press the <RIGHT ARROW> key to move toward the end of the list. Press the <LEFT ARROW> key to move toward the beginning of the list.

CONTINUOUS FIXED TASKS (CONTINUED)

Press the <F1> key to edit the task number, crewmember, start time, and duration of the selected task.

To change an entry, type the new information at the **ENTER:** prompt and press the <ENTER> key.

Press the <ENTER> key if you do not want to change a particular field.

Press the <F9> key to delete the current entry from the list and display the next entry on the screen.

When all entries that describe the continuous fixed tasks are entered, press the <ESC> key to return to the Function Decision Rules Menu.

FUNCTION DECISION RULES (CONTINUED)

When you have completed creating or editing the function decision rules, press the <ESC> key. To make the changes permanent, press the <Y> key in response to the prompt **DO YOU WANT TO SAVE THE NEW RULE? (Y/N)**. If you do not want to save the changes, press the <N> key.

The **ENTER FUNCTION NUMBER:** prompt will be displayed for another function number to be added or edited.

Continue this process until all function decision rules have been added and edited.

Press the <ESC> key to return to the Decision Rules Menu.

SPLIT FUNCTIONS

The current limit on the total number of fixed tasks (both discrete and continuous) in a function decision rule is 40. However, a function with more than 40 discrete fixed or continuous fixed tasks can still be entered by splitting the tasks into two or more groups. Enter the first group as described above. Enter the second and subsequent groups by designating a function number that is larger than the maximum number of functions defined under the System Parameters Menu. When you enter a function number larger than the maximum, you will be asked for a printout number. The printout number indicates the function that the new information will be associated with during execution.

For example, if function number 42 is too large to program in one decision rule and the maximum number of functions is 200, enter part of the decision rule under function number 42 and the rest under function 242. Because 242 is greater than the maximum number of functions in the model, the program will prompt for a printout number. Enter printout number 42 to indicate that function 242 is really an extension of function 42.

2 SEGMENT DECISION RULES

Press the <2> key to enter the Segment Decision Rules.

The name of the current Segment Decision Rule file will be displayed at the top of the screen. At the **ENTER SEGMENT NUMBER:** prompt, enter the number of the segment decision rule that you want to enter or edit and press the <ENTER> key. Use the same number that was paired with the segment names under the Task/Workload Analysis Menu.

A menu will be displayed with the name of the segment and the following options:

1: DISCRETE FIXED FUNCTIONS
2: DISCRETE RANDOM FUNCTIONS
3: CONTINUOUS FIXED FUNCTIONS
ESC: LEAVE MENU

Each of these subroutines is described below.

1

DISCRETE FIXED FUNCTIONS

Press the <1> key to enter or edit the discrete fixed functions in the segment.

An edit screen will be displayed with the segment name and number at the top of the screen, followed by the function number, start time, duration, and interrupt function of the first discrete fixed function. If no functions have been entered, there will be no information beside these prompts.

The bottom of this screen will display a short description of the active commands with the cursor to the right of the **PRESS A KEY:** prompt.

Press the <F5> key to add a new entry at the end of the list or to enter the first entry of a new decision rule. A blank entry will be displayed that allows you to enter the function number, start time, duration, and interrupt list of the new function. The cursor will move to the **FUNCTION:** prompt. Enter the function number and press the <ENTER> key.

Enter the time to begin the function in seconds since the beginning of the segment at the **START:** prompt and press the <ENTER> key. If the current function is to start after another function is completed, enter the lead function's number preceded by a negative sign at the **START:** prompt of the current function.

Enter the length of time in seconds that the function will be performed during the execution of the segment at the **DURATION:** prompt and press the <ENTER> key.

DISCRETE FIXED FUNCTIONS (CONTINUED)

Enter the *interrupt function* at the **INTERRUPT:** prompt and press the <ENTER> key. The interrupt is a random function that will interrupt the currently displayed function during execution. Up to ten function numbers may be entered in the interrupt list prior to returning to the bottom of the screen. If all random functions interrupt the current function, you can specify this by entering the code 999 as the interrupt list. To delete an existing function number from the interrupt list, press the <DEL> key at the **ENTER:** prompt for the number. If no random functions interrupt the discrete fixed function, press <ENTER>.

If the interrupt list has less than 10 entries, press the <ENTER> key without entering a function number to continue.

The <RIGHT ARROW> and <LEFT ARROW> keys move you through the list of functions. Press the <RIGHT ARROW> key to move toward the end of the list. Press the <LEFT ARROW> key to move toward the beginning of the list.

Press the <F1> key to edit the *function*, *start time*, *duration*, and *interrupt list* of the selected function.

To change any entry, type the new information at the **ENTER:** prompt and press the <ENTER> key.

Press the <ENTER> key if you do not want to change a particular field.

Press the <F9> key to delete the selected function from the function list and display the next function on the screen.

When all entries that describe the discrete fixed functions are defined, press the <ESC> key to return to the Segment Decision Rules Menu.

2

DISCRETE RANDOM FUNCTIONS

Press the <2> key to enter or edit the discrete random functions in the segment.

An edit screen will be displayed showing the segment name and number and the function 1 number and duration, function 2 number and duration, start time, finish time, and number of times to be performed for the first discrete random function in the decision rule. If no functions have been entered, there will be no information beside these prompts.

The bottom of this screen will display a short description of the active commands with the cursor to the right of the **PRESS A KEY:** prompt .

Either one or two random functions can be entered. If one function is entered, the program will randomly run that function the number of times specified in the entry during the window of time indicated by the start and finish entries. If two functions are entered, the program will randomly select one from the pair each time the discrete random pair is selected for execution.

Press the <F5> key to add a new function to the end of the list or to enter the first function in a new segment decision rule.

The cursor will move to the **FUNCTION 1:** prompt. Enter the function number and press the <ENTER> key. Enter the length of time in seconds that the function will be performed during the execution of the segment at the **DURATION 1:** prompt and press the <ENTER> key. The cursor will move to the **FUNCTION 2:** prompt. The procedure for entering Function 2 is the same as the procedure for entering Function 1.

To enter only one function, press the <ENTER> key at the **FUNCTION 2:** prompt.

DISCRETE RANDOM FUNCTIONS (CONTINUED)

The cursor will move to the **START:** prompt. Enter the time in seconds since the beginning of the segment to begin the active period and press the <ENTER> key. The cursor will move to the **FINISH:** prompt. Enter the time to end the active period and press the <ENTER> key. Enter the average number of times that the function from the set is to be performed at the **TIMES:** prompt and press the <ENTER> key.

The <RIGHT ARROW> and <LEFT ARROW> keys move you through the list of functions. Press the <RIGHT ARROW> key to move toward the end of the list. Press the <LEFT ARROW> key to move toward the beginning of the list.

Press the <F1> key to edit the specifications of the currently selected function. Press the <ENTER> key if you do not want to change any of the fields.

Press the <F9> key to delete the current entry from the list and display the next entry on the screen.

The current *limit* on the number of discrete random functions is 11.

When all entries that describe the discrete random functions are entered, press the <ESC> key to return to the Segment Decision Rules Menu.

3

CONTINUOUS FIXED FUNCTIONS

Press the <3> key to enter or edit the continuous fixed functions in the segment.

An edit screen will be displayed showing the name and number of the segment and the function number, start time, duration, and interrupt list of the first continuous fixed function in the segment, if there is one.

CONTINUOUS FIXED FUNCTIONS (CONTINUED)

The procedure for entering the continuous fixed functions is the same as the procedure for entering the discrete fixed functions described above, with one exception: To specify that a function is to run until the completion of the segment, enter the value -0.5 at the **DURATION:** prompt.

When all entries that describe the continuous fixed functions are entered, press the <ESC> key to return to the Segment Decision Rules Menu.

2

SEGMENT DECISION RULES (CONTINUED)

When you are finished adding or editing the segment decision rules, press the <ESC> key.

To make the changes permanent, press the <Y> key in response to the prompt DO YOU WANT TO SAVE THE NEW RULE? (Y/N). If you do not want to save the changes, press the <N> key.

The **ENTER SEGMENT NUMBER:** prompt will be displayed for another segment number to be entered. To continue to add or edit segment decision rules, enter the segment number.

The current limit on the number of fixed functions (both discrete and continuous) is 24.

When you have completed entering or editing the segment decision rules, press the <ESC> key to return to the Decision Rules Menu.

3

FUNCTION CLASH PAIRS

Press the <3> key to enter the Function Clash Pairs.

An edit screen will be displayed with the clash file name, the number of clash pairs in the file, and the **FUNCTION 1:** prompt.

Function clash pairs are any two functions in the model that cannot be executed simultaneously. For example, the pilot of an aircraft cannot talk to the copilot and the control tower at the same time.

FUNCTION CLASH PAIRS (CONTINUED)

To determine the content of the clash pairs that are currently in a model, use the Print Files routine under the File Handling Menu to print the clash pairs.

To add or delete a clash pair, enter one of the function numbers at the **FUNCTION 1:** prompt and press the <ENTER> key. Enter the other function number at the **FUNCTION 2:** prompt and press the <ENTER> key.

If the pair is not currently in the file, the prompt **DO YOU WISH TO ADD FUNCTION CLASH PAIR? (Y/N)** will be displayed. If you do, press the <Y> key. If not, press the <N> key.

If the pair is already in the file, the prompt **DO YOU WISH TO KEEP THE FUNCTION CLASH PAIR? (Y/N)** will be displayed. If you wish to delete the pair, press the <N> key. If not, press the <Y> key.

When you have completed adding and deleting function clash pairs, press the <ESC> key to return to the Decision Rules Menu.

Press the <ESC> key to return to the Main Menu.

4 EXECUTE THE MODEL

After constructing and entering a complete model, you can execute each of the segments.

Press the <4> key to run the Execute the Model routine on the Main Menu.

Output. This displays the following Model Output Option Menu:

1. NO OUTPUT FILE
2. SIMULATION LISTING
3. ABBREVIATED SIMULATION LISTING
4. NUMERICAL DATA FILES
5. TASK LISTING

ESC: LEAVE MENU

The output options are described in the paragraphs that follow and examples of each type are presented in Appendix C. Determine the desired output and press the number key beside the appropriate option. Proceed to the description of the randomization given on page 58 to continue the execution process.

The No Output File option is the fastest method of executing the model. This option runs the model and displays the results on the screen, but does not create an output file. The screen displays the number of overload conditions, the number of component overloads, and the overload density for each crewmember (see page C-2 of Appendix C). To obtain a printout of the screen, use the <PRINT SCREEN> key to send a copy of the screen to the printer.

The Simulation Listing output lists each crewmember's current functions and the tasks within those functions for half-second periods along the mission time line (see pages C-3 to C-5 of Appendix C). This option produces a computer file in the model directory named SIM.LST. Task workload is printed for each task and the current workload total is printed for each crewmember. When a new overload condition occurs for a crewmember, the previous overload count is incremented by one and the current count of overload conditions is printed at the right of the page. The task subsystems for the overloaded crewmember are printed below the total line. TRANSITION is printed for the task when a crewmember makes a transition from one task to another task. STANDBY is printed in place of a function when a crewmember is not performing a function. If there is a component conflict (e.g., two tasks require the same hand), a star is printed next to the component total. The last half-second period in the segment time line does not list a function or task and indicates the end of the segment.

The last three pages of the Simulation Listing output file present summary information. The first summary page (see page C-6) lists the total number of overload conditions, the number of component overloads, and the overload density for each crewmember. This summary page provides the same information that is displayed on the screen

when the segment is executed. The second summary page (see page C-7) lists the number of overloads for each subsystem for each crewmember. The third summary page (see page C-8) lists, in five columns, the results from the execution of the random functions. Column 1 is the function number. Column 2 (average time) is the estimated number of times the function is expected to occur. Column 3 (ceiling) is the maximum number of times the random function can be performed. The ceiling is calculated by multiplying the estimated number of occurrences by 1.5. The lower limit of occurrence is set at zero. Column 4 (performed) is the number of times the random function occurred during execution. Column 5 (remaining) is the additional number of times the random function could have been performed before reaching the ceiling.

The Abbreviated Simulation Listing output is similar to the Simulation Listing output except that it prints fewer half-second periods. For example, the Abbreviated Simulation Listing does not print a representation when a new continuous random task is selected. A new point on the time line is printed only if a discrete fixed or a discrete random task changes, or if a new continuous random task creates an overload condition. This option produces a computer file in the model directory named ABS.LST.

The Numerical Data Files output (see page C-9) enables further analyses of the model output (e.g., statistical analysis or graphing). This option produces separate computer files in the model directory for each of the crewmembers defined in the model by combining the single letter crewmember code and WL.LST. For example, if the currently defined crewmembers in the model are PILOT and COPILOT, then this option would produce the files PWL.LST and CWL.LST. The current predictions of each crewmember's workload are written into these files for each half-second of the segment.

The Numerical Data Files differ from the Simulation Listing output in two major ways. First, the files do not contain any description of the tasks or functions being performed during the segment; the files only contain numbers. Second, every half-second of the model execution is represented by a new row of numbers. The first column in the file is always the segment time and is followed by the model's predictions of the crewmember's current workload for each of the components defined in the model. The files are tab delimited ASCII, which allows most text editors and graphic or statistical software to read the file.

The Task Listing output (see page C-10) facilitates a review of the model by experienced personnel to determine whether the model is accurately simulating each crewmember's actions. The Task Listing output lists only the segment time and current task(s) being performed by the crewmember and has no information about the function or the workload. This option produces separate computer files in the model directory for each of the crewmembers defined in the model by combining the single letter crewmember code and TL.LST. For example, if the currently defined crewmembers in the model are PILOT and COPILOT, then this option produces the files PTL.LST and CTL.LST.

Each output option produces a unique file (or set of files) in the model directory. Thus, each time the Execute the Model routine is entered and a particular output option is

chosen, the program overwrites any existing file (or set of files) from previous model executions using the same output option. To save existing output files, use the DOS command RENAME to change the file name or to print the files prior to entering the Execute the Model routine again.

Randomization. After the type of output is entered, the **DO YOU WISH TO RANDOMIZE YOUR SEGMENTS? (Y/N)** prompt is displayed.

If you press the <Y> key, the number of times and the start times that the random functions and tasks are executed are different each time a segment is run.

If you press the <N> key, the random functions and random tasks are performed the same number of times and occur at the same time in each segment run. This is useful for comparing different runs of the same segment (e.g., using different overload thresholds or different modification options).

Execution. After the type of randomization is entered, the **ENTER SEGMENT #:** prompt is displayed. To execute a segment in the model, enter the segment number and press the <ENTER> key.

A summary screen is displayed throughout the segment run. The screen displays the model name, the segment title, the segment number, the segment time (which changes throughout the segment and indicates the model is running), and the current number of overload conditions and component overloads for each crewmember.

If any of the decision rules refer to a crewmember who is not currently defined in the model, the following message is displayed on the screen: **WARNING: TASK IN DECISION RULE HAS INVALID CREWMEMBER.** This is an advisory message and will not interrupt the segment run.

When the segment run is completed, the overload density is displayed for the segment and the **SEGMENT COMPLETED ... PRESS A KEY:** prompt is displayed. Press any key and the **ENTER SEGMENT #:** prompt is displayed.

To use the same randomization mode and to append to the same output file, enter the new segment number and press <ENTER>.

To (a) change the randomization mode, (b) start a new output file, or (c) close a different output option, return to the Main Menu by pressing the <ESC> key and select the Execute the Model routine again.

5 File Handling

Use the File Handling Menu to:

- change any of the default names used to store model data,
- print the data that defines the model, and
- access the Directory Utility to change to a different model.

Press the <5> key to execute the File Handling routine on the Main Menu. This will display the following File Handling Menu:

1: Select Files
2: Print Files
3: Directory Utility
ESC: Leave Menu

1 Select Files

Press the <1> key to change the names of the computer files used to store the model.

A Select File Menu showing a list of 8 file names used to store the data is displayed.

(Note: You are strongly discouraged from changing any of the default file names using this menu. To work with different models, set up separate subdirectories for each model.)

To change any of the file names, enter the number beside the file name. The selected file name will be displayed at the top of the screen along with a list of all the file names in the current model's disk directory.

There are two ways to change the file name. In the first method, press the <BACKSPACE> key to remove the old file name; then type the new name and press the <ENTER> key.

The second method uses a new name that already exists in the list of files. To select a file name already in use, press the <TAB> key and the first file name in the list of files in the directory will be highlighted. Use the <UP ARROW> or <DOWN ARROW> keys to highlight the desired file name and press the <ENTER> key.

SELECT FILES (CONTINUED)

The selected file name is changed and the new name appears on the Select File Menu.

To return to the first method of changing the file name, press the <TAB> key again.

To exit the routine without changing the file name from either mode, press the <ESC> key.

When you have completed changing file names, press the <ESC> key to return to the File Handling Menu.

2 PRINT FILES

A printer must be attached to your computer to use this routine.

Press the <2> key to print the model data. The following Print Menu will be displayed:

1: PRINT TASK NAMES
2: PRINT FUNCTION NAMES
3: PRINT SEGMENT NAMES
4: PRINT SEGMENT DECISION RULES
5: PRINT FUNCTION DECISION RULES
6: PRINT TASK SUBSYSTEMS
7: PRINT TASK WORKLOADS
8: PRINT FUNCTION CLASH PAIRS
9: PRINT OUTPUT FILES
ESC: LEAVE MENU

To print the information contained in one of the first 8 options in the menu, enter the appropriate number on the menu and the file will begin printing. Appendix B contains examples of the output produced by using the first 8 options in the menu.

The procedure for printing the output files is somewhat different, because there are many possible output files. Press the <9> key to select an output file to print. The screen will display the names of all the LST files in the current directory and the prompt **ENTER THE OUTPUT FILE TO PRINT:**.

PRINT FILES (CONTINUED)

There are two ways to enter the file name. To use the first method, type the file name and then press the <ENTER> key. If the file exists, it will begin printing.

To use the second method, press the <TAB> key and the first file in the directory will be highlighted. Use the <UP ARROW> or <DOWN ARROW> keys to highlight the file you want to print and then press the <ENTER> key to begin printing.

To return to the first method, press the <TAB> key again.

To exit the routine without printing a file from either mode, press the <ESC> key.

When all printing is finished, press the <ESC> key to return to the File Handling Menu.

3

DIRECTORY UTILITY

Press the <3> key to enter the Directory Utility. This allows you to change from one model to another. The **ENTER DRIVE A-E:** *prompt will be displayed.*

To change to a different model, enter the drive A-E where the model is stored. The directory structure of that drive is displayed on the screen. Use the arrow keys to highlight the desired directory (model) and press the <ENTER> key. This connects you to the new model and returns you to the File Handling Menu.

The Directory Utility routine can also be used to delete and rename files. After selecting the drive and highlighting a directory, press the <F> key to display a list of the files in that directory with the first file highlighted.

To rename or delete a file, use the <UP ARROW> or <DOWN ARROW> keys to highlight the file, then press the <R> key to rename the file or the <D> key to delete the file.

If you press the <R> key to rename the file, the program asks for a new name. Enter the new name and press the <ENTER> key to rename the file.

DIRECTORY UTILITY (CONTINUED)

If you press the <D> key, the program asks for confirmation before deleting the file. Press the <Y> key and the file is deleted. Press the <N> key and the delete command is rescinded.

When the renaming and deleting of files in the directory are completed, press the <ESC> key to return to the graphic representation of the directories on the disk drive. Select another directory or press the <ENTER> key to return to the File Handling Menu.

6 MOVE TO A DIFFERENT MODEL

After working with one model, you may want to change to a different model without leaving TOSS.

Press the <6> key to execute the Move to a Different Model routine on the Main Menu. This option executes the Directory Utility routine that allows you to change from one model to another.

To change to a different model, enter the drive A-E where the model is stored. The directory structure of that drive is displayed on the screen. Use the arrow keys to highlight the desired subdirectory (model) and press the <ENTER> key. This returns you to the Main Menu ready to work with the new model.

To exit the Directory Utility without changing the model, press the <ESC> key.

GLOSSARY

ACTIVE PERIOD — The span of time in which a random task or function is allowed to occur.

COMPONENT OVERLOAD — Each half-second period in which a workload component exceeds the overload threshold established in the model. The number of component overloads is computed separately for each crew-member defined in the model.

CONTINUOUS — Describes tasks whose magnitude or intensity of performance determine the magnitude of the resulting system response. The resulting state of the system in turn determines the magnitude or intensity of the subsequent performance of the task. Continuous tasks occur in closed-loop control systems. Mission requirements and conditions determine their start and end points. In TAWL, continuous is used in contrast to discrete.

DECISION RULES — A list of temporal sequencing information that describes the execution of tasks within a function or the execution of functions within a segment. A decision rule contains either a start time and finish time or a start time and duration.

DISCRETE — Tasks whose magnitude or intensity of performance does not determine the magnitude of the resulting system change. Discrete tasks occur in open-loop control systems. In TAWL, discrete is used in contrast to continuous.

FIXED — Describes tasks or functions that occur in a specified sequence rather than a random sequence.

FUNCTION — The collection of crewmember's actions that are necessary to carry out a single logical activity. Functions are interruptible parts of a segment that may be present in different segments. Functions can be concurrent with or sequential to other functions in a segment. Functions are composed of tasks. Examples of functions include perform before-taxi check and check instrument panel.

CLASH PAIRS A pair of functions that cannot be performed concurrently. For example, in the attack helicopter, the copilot/gunner cannot perform the track targets automatically function and the track targets manually function at the same time.

INTERRUPT An interrupt occurs when the performance of one function is stopped temporarily in order to perform another one. For example, monitoring the external visual scene may be interrupted to check the instrument panel.

MISSION An operation of the system that is designed to accomplish a broad objective. Because there are several ways to accomplish that objective, a composite mission can be developed from several unique mission profiles (e.g., different routes, different targets). The composite mission contains as many operations as possible that are common to the various missions. A mission is composed of phases, segments, functions, and tasks. Examples of missions include seeking out and destroying enemy targets, and transporting personnel and cargo from one point to another.

OVERLOAD A theoretical construct defined as the point at which an operator's attentional resources are so depleted by current task demands that performance on one or more of the tasks is degraded.

OVERLOAD CONDITION A period of time when one or more component overloads have occurred. An overload condition is counted each time a change in the tasks contributing to a component overload occurs. The number of overload conditions is computed separately for each crewmember defined in the model.

OVERLOAD DENSITY The percentage of time that an overload condition has occurred during a mission segment. The overload density is computed separately for each crewmember defined in the model.

OVERLOAD THRESHOLD A value established in the model (the default is 8) that determines the point at which a component overload occurs. TOSS maintains an overload threshold for each workload component. Each component overload threshold is defined for all crewmembers in the model.

PHASE A temporally discrete, uninterruptible, and nonrepeating part of a mission. A phase is a required, logical part of a mission that may be accomplished in several ways. Phases must be sequential to other phases (i.e., they do not occur concurrently) and must be contiguous. All portions of the mission are encompassed under one of the mission phases and every phase must be performed to accomplish the mission. Thus, the mission is composed of a sequence of phases placed end to end. Phases are composed of segments, functions, and tasks. Examples of phases include preflight, departure, enroute, and target servicing.

RANDOM Describes two different aspects of tasks or functions: (a) they may occur at any time as opposed to a fixed time and (b) they may occur a variable number of times. In TAWL, random is used in contrast to fixed.

SEGMENT A temporally discrete, uninterruptible part of a phase. A segment represents a particular method of accomplishing a part of a phase. Segments must be sequential to other segments and must be contiguous. Several segments may represent a variety of methods used to complete a portion of the phase; thus, every segment within the phase may not need to be performed to complete the phase. Segments may be repeated in other phases. Segments are composed of functions and tasks. Examples of segments include contour flight, and approach.

SUBSYSTEM A collection of mechanical, electrical, or computational equipment with which a crewmember must interact to perform a function. A subsystem is a component of a subsystem group. Examples of subsystems include brakes, hydraulics, and rotor.

SUBSYSTEM GROUP Two or more interacting, interrelated, or interdependent subsystems. Subsystems are maintained in TOSS as parts of subsystem groups. Examples of subsystem groups include navigation and flight control.

SUBSYSTEM OVERLOAD The number of times that a subsystem is associated with a component overload.

SYSTEM The entire collection of equipment with which a crewmember must interact to accomplish a mission. Systems are composed of subsystem groups. Examples of systems include aircraft, tank, and automobile.

TASK	A noninterruptible crew activity that is essential to the successful completion of a function. The task is the basic element in the decomposition of a mission. Examples of tasks include: adjust CRT intensity, set collective friction, and control altitude.
WORKLOAD	The total attentional demand required by all current tasks and responsibilities of an operator in a system. Attention is assumed to have several components. Workload is assessed for each component.
WORKLOAD COMPONENT	One of several attentional resources that can be temporarily depleted by task demands. Examples of workload components include cognitive, psychomotor, and sensory.
WORKLOAD COMPONENT SPECIFIER	A single character that further categorizes a workload component. For example, the psychomotor workload component might have two workload component specifiers, L for left hand and R for right hand.

APPENDIX A

EXAMPLE WORKLOAD RATING SCALES

WORKLOAD COMPONENT SCALES

Scale Value	Verbal Descriptor
	Cognitive
1.0	Automatic (Simple Association)
1.2	Alternative Selection
3.7	Sign/Signal Recognition
4.6	Evaluation/Judgment (Consider Single Aspect)
5.3	Encoding/Decoding, Recall
6.8	Evaluation/Judgment (Consider Several Aspects)
7.0	Estimation, Calculation, Conversion
	Visual
1.0	Visually Register/Detect (Detect Occurrence of Image)
3.7	Visually Discriminate (Detect Visual Differences)
4.0	Visually Inspect/Check (Discrete Inspection/Static Condition)
5.0	Visually Locate/Align (Selective Orientation)
5.4	Visually Track/Follow (Maintain Orientation)
5.9	Visually Read (Symbol)
7.0	Visually Scan/Search/Monitor (Continuous/Serial Inspection, Multiple Conditions)
	Auditory
1.0	Detect/Register Sound (Detect Occurrence of Sound)
2.0	Orient to Sound (General Orientation/Attention)
4.2	Orient to Sound (Selective Orientation/Attention)
4.3	Verify Auditory Feedback (Detect Occurrence of Anticipated Sound)
4.9	Interpret Semantic Content (Speech)
6.6	Discriminate Sound Characteristics (Detect Auditory Differences)
7.0	Interpret Sound Patterns (Pulse Rates, etc.)
	Kinesthetic
1.0	Detect Discrete Activation of Switch (Toggle, Trigger, Button)
4.0	Detect Preset Position or Status of Object
4.8	Detect Discrete Adjustment of Switch (Discrete Rotary or Discrete Lever Position)
5.5	Detect Serial Movements (Keyboard Entries)
6.1	Detect Kinesthetic Cues Conflicting With Visual Cues
6.7	Detect Continuous Adjustment of Switches (Rotary Rheostat, Thumbwheel)
7.0	Detect Continuous Adjustment of Controls

WORKLOAD COMPONENT SCALES (continued)

Scale Value	Verbal Descriptor
	Psychomotor
1.0	Speech
2.2	Discrete Actuation (Button, Toggle, Trigger)
2.6	Continuous Adjustive (Flight Control, Sensor Control)
4.6	Manipulative
5.8	Discrete Adjustive (Rotary, Vertical Thumbwheel, Lever Position)
6.5	Symbolic Production (Writing)
7.0	Serial Discrete Manipulation (Keyboard Entries)
	Night Vision Goggles
1.0	Visually Register/Detect (Detect Occurrence of Image With NVG)
4.8	Visually Inspect/Check (Discrete Inspection/Static Condition) With NVG
5.0	Visually Discriminate (Detect Visual Differences) With NVG
5.6	Visually Locate/Align (Selective Orientation) With NVG
6.4	Visually Track/Follow (Maintain Orientation) With NVG
7.0	Visually Scan/Search/Monitor (Continuous/Serial Inspection, Multiple Conditions) With NVG

APPENDIX B

EXAMPLE OUTPUT OF MODEL DATA BASE

1. PRINT TASK NAMES

AH-64 Apache Task Analysis / WorkLoad Model
File: C:\TAWL\AH-64\TASK.DAT

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1. Set Accelerometer
2. Note Acknowlegment
3. Transmit Acknowledgment
4. Check ACM Switch
5. Set ACM Switch
6. Check ACQ SEL Switch (G)
7. Set ACQ SEL Switch (G)
8. Check ACQ SEL Switch (P)
9. Set ACQ SEL Switch (P)
10. Check ADF Control Switch
11. Set ADF Control Switch
12. Check ADF Operation
13. Check ADSS Switch
14. Set ADSS Switch
15. Check Aft Gravity Fuel Cap
16. Check Aft Stowage Bay
17. Check Aft Tailboom
18. Check Air Data Sensor
19. Stabilize Aircraft
20. Maneuver Aircraft Across Landmark
21. Check Aircraft Covers
22. Position Aircraft in Constraints
23. Position Aircraft into Wind
24. Check Aircraft Location (G)
25. Verify Aircraft Location (G)
26. Check Aircraft Location (P)
27. Transmit Aircraft Status
28. Survey Aircraft Surroundings (G)
29. Survey Aircraft Surroundings (P)
30. Position Aircraft Toward Target
31. Control Airspeed
32. Check Airspeed Indicator
33. Change Airspeed Quickly
34. Set Altimeter
35. Adjust Altitude
36. Control Altitude
37. Increase Altitude
38. Change Altitude Sharply
39. Check Ammunition Bay Access
40. Set AN / APR 39
41. Check AND Display (Laser Code)
42. Check AND Display (LMC)
43. Check AND Display (Missile)
44. Check AND Display (Offset)
45. Check AND Display (Polarity)
46. Check AND Display (Priority)
47. Check AND Display (Search)
48. Check AND Display (Tracking)
49. Check Anticollision Light Switch
50. Check Anti-ice Control Switch
51. Check Anti-ice Test Switch
52. Initialize APU
53. Check APU Control Switch
54. Set APU Control Switch
55. Check APU Exhaust

2. PRINT FUNCTION NAMES

1. Acquire Target (DTV)
2. Acquire Target (DTV, Laser Spot Tracker, Automatic)
3. Acquire Target (DTV, Laser Spot Tracker, Manual)
4. Acquire Target (DVO)
5. Acquire Target (DVO, Laser Spot Tracker, Automatic)
6. Acquire Target (DVO, Laser Spot Tracker, Manual)
7. Acquire Target (FLIR)
8. Acquire Target (FLIR, Laser Spot Tracker, Automatic)
9. Acquire Target (FLIR, Laser Spot Tracker, Manual)
10. Activate Ignition
11. Adjust IHADSS Boresight (Gunner)
12. Adjust IHADSS Boresight (Pilot)
13. Adjust Outfront Boresight
14. Arrange Cockpit (Gunner)
15. Arrange Cockpit (Pilot)
16. Change Battle Position
17. Check Aircraft Systems (Gunner)
18. Check Aircraft Systems (Pilot)
19. Check Area Security (Sensor Search)
20. Check Area Security (Visual Search)
21. Check Armament Subsystems (Gunner)
22. Check Armament Subsystems (Pilot)
23. Check Cockpit Conditions (Gunner)
24. Check Cockpit Conditions (Pilot)
25. Check Collective Switches (Gunner)
26. Check Collective Switches (Pilot)
27. Check Engine 1 ECU Lockout System
28. Check Engine 2 ECU Lockout System
29. Check Engine Chop Circuit
30. Check Fuel Sample
31. Check Helmet (Gunner)
32. Check Helmet (Pilot)
33. Check Instrument Panel (Gunner)
34. Check Instrument Panel (Pilot)
35. Check Left Control Console (Gunner)
36. Check Left Control Console (Pilot)
37. Check Left Side - Fuselage and Nose
38. Check Left Side - Mast
39. Check Left Side - Rear Fuselage
40. Check Left Side - Wing
41. Check Overhead Panel
42. Check Right Control Console (Gunner)
43. Check Right Control Console (Pilot)
44. Check Right Side - Mast
45. Check Right Side - Rear Fuselage
46. Check Right Side - Under Fuselage
47. Check Right Side - Wing
48. Check Security Devices
49. Complete TAMMS Forms
50. Compute Fuel Burn Rate
51. Conduct Postflight Walk Around
52. Consolidate Forces
53. Coordinate Mission
54. Deactivate APU
55. Designate Target (Autonomous)

3. PRINT SEGMENT NAMES

1. Flight Planning
2. Exterior Cockpit Check
3. Preflight Walk Around
4. Interior Cockpit Check
5. Starting APU
6. After Starting APU
7. Taxi
8. Takeoff (Contour)
9. Contour Flight
10. NOE Flight
11. Approach (Contour)
12. Approach (NOE)
13. Landing
14. Holding Area Operations (Inbound)
15. Holding Area Operations (Outbound)
16. Takeoff (NOE)
17. Establishment of Battle Position
18. Deployment in Battle Area
19. Target Handover (Laser Spot Tracker)
20. Target Handover, Grid (Missile)
21. Target Handover, Grid (Gun, Pilot)
22. Target Handover, Grid (Gun, Gunner)
23. Target Handover, Grid (Gun, Gunner, Laser Range)
24. Target Handover, Grid (FFAR, Pilot)
25. Target Handover, Grid (FFAR, Cooperative)
26. Acquisition (DTV)
27. Acquisition (DTV, Laser Spot Tracker, Manual)
28. Acquisition (DTV, Laser Spot Tracker, Automatic)
29. Acquisition (DVO)
30. Acquisition (DVO, Laser Spot Tracker, Manual)
31. Acquisition (DVO, Laser Spot Tracker, Automatic)
32. Acquisition (FLIR)
33. Acquisition (FLIR, Laser Spot Tracker, Manual)
34. Acquisition (FLIR, Laser Spot Tracker, Automatic)
35. Engagement, LOAL / Autonomous (Track Target, Manual)
36. Engagement, LOAL / Autonomous (Track Target, Image Autotracker)
37. Engagement, LOAL / Autonomous (Track Target, Image Autotracker Off
38. Engagement, LOAL / Remote Designation
39. Engagement, LOBL / Autonomous (Track Target, Manual)
40. Engagement, LOBL / Autonomous (Track Target, Image Autotracker)
41. Engagement, LOBL / Autonomous (Track Target, Image Autotracker Off
42. Engagement, LOBL / Remote Designation
43. Engagement, Gun (Pilot, Normal)
44. Engagement, Gun (Gunner, Normal)
45. Engagement, Gun (Gunner, Normal, TADS Laser Range)
46. Engagement, FFAR (Pilot, Normal)
47. Engagement, FFAR (Cooperative, Normal, TADS Laser Range)
48. Engagement, LOAL / Rapid Fire
49. Engagement, LOAL / Ripple Fire
50. FARP Procedures
51. Engine Shutdown
52. Before Leaving Aircraft

AH-64 Apache Task Analysis / WorkLoad Model
File: C:\TAWL\AH-64\BLDSEG.DAT

Segment 16: Takeoff (NOE)

Discrete Fixed Functions

Entry #	Function #	Function Name	Start	Duration	Interrupt
2	161	Perform Before Hover Check	0.0	182.5	78 79 84
3	162	Establish Hover	-161.0	8.0	18 84
4	96	Perform Before Takeoff Check (Pilot)	-105.0	48.5	18 78 79 84
5	60	Establish Climb	-96.0	8.0	18 84
6	61	Establish Level of Flight	-164.0	6.0	18 84
7	95	Perform Before Takeoff Check (Gunner)	-105.0	20.0	17 78 79
8	103	Perform External Communication (Gunner)	-95.0	28.0	
9	169	Check Fuel Consumption Parameters	-60.0	7.0	17

Continuous Fixed Functions

Entry #	Function #	Function Name	Start	Duration	Interrupt
1	83	Monitor Audio	0.0	-0.5	
10	105	Perform Hover	-162.0	120.0	18 84
11	163	Monitor Flight Controls	-105.0	48.5	18 84
12	164	Adjust Climb Parameters	-60.0	30.0	18 84
13	168	Adjust Level of Flight Parameters	-61.0	60.0	18 84 167

Discrete Random Functions

Entry #	Function #	Function Name	Duration	Start	Finish	Times
1	78	Initiate Cockpit Communication (Gunner)	7.0	0.0	-0.5	4
	79	Initiate Cockpit Communication (Pilot)	7.0			
2	84	Monitor Threat	3.5	0.0	-0.5	2
3	18	Check Aircraft Systems (Pilot)	7.5	-161.0	-0.5	1
4	84	Monitor Threat	3.5	0.0	-0.5	2
5	17	Check Aircraft Systems (Gunner)	11.0	0.0	-0.5	1
6	165	Check Climb Parameters	1.0	-60.0	30.0	4
7	167	Check Level of Flight Parameters	1.0	-61.0	60.0	8

AH-64 Apache Task Analysis / WorkLoad Model
File: C:\TAWL\AH-64\BLDFUN.DAT

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Function 80: Land Aircraft

Discrete Fixed Tasks

Entry #	Task #	Task Name	Operator	Start	Duration
1	593	Perform Touchdown	PILOT (P)	10.5	3.0

Discrete Random Tasks

Start : 0.0
Finish: 10.0
Operator: GUNNER (G)

Times: 5
Interrupt: N

Entry #	Task #	Task Name	Duration
1	690	Check Obstacle Clearance	1.0

Continuous Random Tasks

Start : 0.0
Finish: 10.0
Operator: PILOT (P)

Entry #	Task #	Task Name	Duration
1	65	Control Attitude	0.5
2	160	Control Drift	0.5
3	305	Control Heading	0.5
4	439	Maintain Obstacle Clearance	0.5
5	466	Adjust Power	0.5

6. PRINT TASK SUBSYSTEMS

1.	FI		
2.	UC		
3.	UC		
4.	VSC		
5.	VSC		
6.	VSC		
7.	VSC		
8.	VSC		
9.	VSC		
10.	NC		
11.	NC		
12.	NC		
13.	AFC		
14.	AFC		
15.	EF		
16.	FA		
17.	FA		
18.	AFC		
19.	FC	VEX	
20.	FC	VEX	
21.	SG		
22.	FC	VSD	
23.	FC	VEX	
24.	ND	NM	VSD
25.	VEX		
26.	VEX		
27.	UC		
28.	VSD		
29.	VEX		
30.	FC		
31.	FC		
32.	FI		
33.	FC	VEX	
34.	FI		
35.	FC	VEX	
36.	FC	VEX	
37.	FC	VEX	
38.	FC	VEX	
39.	FA		
40.	US		
41.	AFC		
42.	AFC		
43.	AFC		
44.	AFC		
45.	AFC		
46.	AFC		
47.	AFC		
48.	AFC		
49.	UL		
50.	UAI		
51.	UAI		
52.	UAP		
53.	UAP		
54.	UAP		
55.	UAP		

7. PRINT TASK WORKLOADS

AH-64 Apache Task Analysis / WorkLoad Model
File: C:\TAWL\AH-64\WORKLOAD.DAT

1.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 3.0	Psy 1.0R
2.	Aud 4.0	Kin 0.0	Vis 0.0	Cog 4.0	Psy 0.0
3.	Aud 4.0	Kin 2.0R	Vis 0.0	Cog 4.0	Psy 3.0R
4.	Aud 0.0	Kin 0.0	Vis 2.0I	Cog 2.0	Psy 0.0
5.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 3.0	Psy 1.0L
6.	Aud 0.0	Kin 0.0	Vis 2.0I	Cog 2.0	Psy 0.0
7.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 3.0	Psy 2.0L
8.	Aud 0.0	Kin 0.0	Vis 2.0I	Cog 2.0	Psy 0.0
9.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 3.0	Psy 1.0L
10.	Aud 0.0	Kin 0.0	Vis 2.0I	Cog 2.0	Psy 0.0
11.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 3.0	Psy 2.0R
12.	Aud 5.0	Kin 0.0	Vis 3.0I	Cog 2.0	Psy 2.0R
13.	Aud 0.0	Kin 0.0	Vis 2.0I	Cog 2.0	Psy 0.0
14.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 3.0	Psy 1.0L
15.	Aud 0.0	Kin 0.0	Vis 2.0E	Cog 2.0	Psy 0.0
16.	Aud 0.0	Kin 0.0	Vis 2.0E	Cog 2.0	Psy 0.0
17.	Aud 0.0	Kin 0.0	Vis 2.0E	Cog 2.0	Psy 0.0
18.	Aud 0.0	Kin 0.0	Vis 2.0E	Cog 2.0	Psy 0.0
19.	Aud 0.0	Kin 4.0R	Vis 3.0E	Cog 1.0	Psy 4.0R
20.	Aud 0.0	Kin 4.0R	Vis 4.0E	Cog 6.0	Psy 4.0R
21.	Aud 0.0	Kin 0.0	Vis 2.0E	Cog 2.0	Psy 0.0
22.	Aud 0.0	Kin 4.0F	Vis 3.0I	Cog 1.0	Psy 4.0F
23.	Aud 0.0	Kin 4.0F	Vis 4.0E	Cog 1.0	Psy 4.0F
24.	Aud 0.0	Kin 0.0	Vis 7.0I	Cog 6.0	Psy 4.0R
25.	Aud 0.0	Kin 0.0	Vis 7.0E	Cog 6.0	Psy 4.0R
26.	Aud 0.0	Kin 0.0	Vis 3.0E	Cog 5.0	Psy 0.0
27.	Aud 4.0	Kin 2.0R	Vis 0.0	Cog 4.0	Psy 3.0R
28.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 5.0	Psy 4.0R
29.	Aud 0.0	Kin 0.0	Vis 3.0E	Cog 5.0	Psy 0.0
30.	Aud 0.0	Kin 4.0F	Vis 4.0E	Cog 1.0	Psy 4.0F
31.	Aud 0.0	Kin 4.0B	Vis 1.0E	Cog 1.0	Psy 4.0B
32.	Aud 0.0	Kin 0.0	Vis 2.0I	Cog 2.0	Psy 0.0
33.	Aud 0.0	Kin 4.0B	Vis 3.0E	Cog 1.0	Psy 4.0B
34.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 3.0	Psy 2.0R
35.	Aud 0.0	Kin 4.0L	Vis 1.0E	Cog 1.0	Psy 4.0L
36.	Aud 0.0	Kin 4.0L	Vis 1.0E	Cog 1.0	Psy 4.0L
37.	Aud 0.0	Kin 4.0L	Vis 3.0E	Cog 1.0	Psy 4.0L
38.	Aud 0.0	Kin 4.0B	Vis 3.0E	Cog 1.0	Psy 4.0B
39.	Aud 0.0	Kin 0.0	Vis 2.0E	Cog 2.0	Psy 0.0
40.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 3.0	Psy 2.0R
41.	Aud 0.0	Kin 0.0	Vis 7.0I	Cog 4.0	Psy 0.0
42.	Aud 0.0	Kin 0.0	Vis 7.0I	Cog 4.0	Psy 0.0
43.	Aud 0.0	Kin 0.0	Vis 7.0I	Cog 4.0	Psy 0.0
44.	Aud 0.0	Kin 0.0	Vis 7.0I	Cog 4.0	Psy 0.0
45.	Aud 0.0	Kin 0.0	Vis 7.0I	Cog 4.0	Psy 0.0
46.	Aud 0.0	Kin 0.0	Vis 7.0I	Cog 4.0	Psy 0.0
47.	Aud 0.0	Kin 0.0	Vis 7.0I	Cog 4.0	Psy 0.0
48.	Aud 0.0	Kin 0.0	Vis 7.0I	Cog 4.0	Psy 0.0
49.	Aud 0.0	Kin 0.0	Vis 2.0I	Cog 2.0	Psy 0.0
50.	Aud 0.0	Kin 0.0	Vis 2.0I	Cog 2.0	Psy 0.0
51.	Aud 0.0	Kin 0.0	Vis 2.0I	Cog 2.0	Psy 0.0
52.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 3.0	Psy 1.0R
53.	Aud 0.0	Kin 0.0	Vis 2.0I	Cog 2.0	Psy 0.0
54.	Aud 0.0	Kin 0.0	Vis 3.0I	Cog 3.0	Psy 1.0R
55.	Aud 0.0	Kin 0.0	Vis 2.0E	Cog 2.0	Psy 0.0

8. PRINT FUNCTION CLASH PAIRS

```
AH-64 Apache Task Analysis / WorkLoad Model                                      Page  1
File: C:\TAWL\AH-64\CLASHES.DAT                                         April 26, 1989

Pair #  1:    17,   50
Pair #  2:    17,   78
Pair #  3:    17,   79
Pair #  4:    17,  103
Pair #  5:    17,  122
Pair #  6:    18,   84
Pair #  7:    18,  104
Pair #  8:    18,  123
Pair #  9:    18,  126
Pair # 10:    78,   84
Pair # 11:    78,  104
Pair # 12:    78,  123
Pair # 13:    78,  126
Pair # 14:    79,   84
Pair # 15:    79,  104
Pair # 16:    79,  123
Pair # 17:    79,  126
Pair # 18:    84,  104
Pair # 19:    84,  123
Pair # 20:    84,  126
Pair # 21:    50,  122
Pair # 22:    78,  122
Pair # 23:    79,  122
Pair # 24:   103,  122
Pair # 25:   122,  158
Pair # 26:   123,  126
Pair # 27:   103,  123
Pair # 28:   104,  123
Pair # 29:   122,  123
Pair # 30:    78,  161
Pair # 31:    79,  161
Pair # 32:    17,  161
Pair # 33:   122,  161
Pair # 34:    79,  158
Pair # 35:    78,  158
Pair # 36:    78,   88
Pair # 37:    79,   88
Pair # 38:    78,  103
Pair # 39:    79,  103
Pair # 40:    17,   88
Pair # 41:    50,   78
Pair # 42:    50,   79
Pair # 43:    88,  122
Pair # 44:    17,  158
Pair # 45:    17,  157
Pair # 46:    78,  157
Pair # 47:    79,  157
Pair # 48:    18,   78
Pair # 49:    18,   79
Pair # 50:    78,   79
Pair # 51:    13,   78
Pair # 52:    13,   79
Pair # 53:    18,  165
Pair # 54:    18,  167
Pair # 55:    84,  165
```

APPENDIX C

EXAMPLE OUTPUT OPTIONS

1. NO OUTPUT FILE

```
Model: AH-64 Apache Task Analysis / WorkLoad Model

Segment Title: Engagement, LOBL / Remote Designation
Segment Number: 42

Segment Time: 65.0

                           PILOT     GUNNER

Overload Conditions:         5          0

Component Overloads
               Aud:          0          0
               Kin:          5          0
               Vis:          0          0
               Cog:          0          0
               Psy:          5          0

( No Output File )

Overload Density =         9.2%       0.0%

Segment Completed ... Press a key.
```

2-3. SIMULATION LISTINGS

AH-64 Apache Task Analysis / WorkLoad Model

April 26, 1989

Segment Number: 42
Segment Title: Engagement, LOBL / Remote Designation

Cum. Secs.		Aud	Kin	Vis	Cog	Psy	OL cond
	PILOT						
0.0	Function 76: Hover Unmasked						
	640 Check Weapon Path	0.0	0.0	3.0E	2.0	0.0	
0.0	Function 83: Monitor Audio						
	66 Monitor Audio	1.0	0.0	0.0	1.0	0.0	
	Workload Totals:	1.0	0.0	3.0	3.0	0.0	
	GUNNER						
0.0	Function 155: Transmit Message (Attack Coordination)						
	413 Transmit Message Alert	4.0	2.0R	0.0	4.0	3.0R	
0.0	Function 83: Monitor Audio						
	66 Monitor Audio	1.0	0.0	0.0	1.0	0.0	
	Workload Totals:	5.0	2.0	0.0	5.0	3.0	

AH-64 Apache Task Analysis / WorkLoad Model

Segment Number: 42 April 26, 1989
Segment Title: Engagement, LOBL / Remote Designation

Cum. Secs.		Aud	Kin	Vis	Cog	Psy	OL cond
	PILOT						
2.5	Function 83: Monitor Audio						
	66 Monitor Audio	1.0	0.0	0.0	1.0	0.0	
2.5	Function 84: Monitor Threat						
	691 Monitor Flight Controls	0.0	1.0B	0.0	1.0	1.0B	
	148 Check Direction Display	0.0	0.0	1.0I	2.0	0.0	
	Workload Totals:	1.0	1.0	1.0	4.0	1.0	
	GUNNER						
2.5	Function 155: Transmit Message (Attack Coordination)						
	413 Transmit Message Alert	4.0	2.0R	0.0	4.0	3.0R	
2.5	Function 83: Monitor Audio						
	66 Monitor Audio	1.0	0.0	0.0	1.0	0.0	
	Workload Totals:	5.0	2.0	0.0	5.0	3.0	

```
AH-64 Apache Task Analysis / WorkLoad Model                                   Page  10

Segment Number: 42                                                           April 26, 1989
Segment Title: Engagement, LOBL / Remote Designation
Cum. Secs.                                              Aud  Kin  Vis  Cog  Psy      OL cond

             PILOT
 24.0  Function  76: Hover Unmasked

       640 Check Weapon Path                            0.0  0.0  3.0E 2.0  0.0

 24.0  Function  83: Monitor Audio

        66 Monitor Audio                                1.0  0.0  0.0  1.0  0.0
                                                       ------------------------------
             Workload Totals:                           1.0  0.0  3.0  3.0  0.0

             GUNNER
 24.0  Function  83: Monitor Audio

        66 Monitor Audio                                1.0  0.0  0.0  1.0  0.0
                                                       ------------------------------
             Workload Totals:                           1.0  0.0  0.0  1.0  0.0

             PILOT
 31.5  Function  83: Monitor Audio

        66 Monitor Audio                                1.0  0.0  0.0  1.0  0.0

 31.5  Function  82: Mask Aircraft

       439 Maintain Obstacle Clearance                  0.0  4.0R 4.0E 1.0  4.0R

 31.5  Function 115: Place Aircraft in Constraints

        22 Position Aircraft in Constraints             0.0  4.0F 3.0I 1.0  4.0F
                                                       ------------------------------
             Workload Totals:                           1.0  8.0  7.0* 3.0  8.0         1
             Subsystems (PILOT):     FC  UC  US  VEX VSD

             GUNNER
 31.5  Function  83: Monitor Audio

        66 Monitor Audio                                1.0  0.0  0.0  1.0  0.0
                                                       ------------------------------
             Workload Totals:                           1.0  0.0  0.0  1.0  0.0
```

```
AH-64 Apache Task Analysis / WorkLoad Model                                    Page 21

Segment Number: 42                                                    April 26, 1989
Segment Title: Engagement, LOBL / Remote Designation

      PILOT

The Total Number of Overload Conditions is: 5

                      Auditory Overloads      =  0
                      Kinesthetic Overloads   =  5
                      Visual Overloads        =  0
                      Cognitive Overloads     =  0
                      Psychomotor Overloads   =  5

Total Number of Overload Lines = 12
Total Number of Lines = 130

Overload Density =   9.2%

      GUNNER

The Total Number of Overload Conditions is: 0

                      Auditory Overloads      =  0
                      Kinesthetic Overloads   =  0
                      Visual Overloads        =  0
                      Cognitive Overloads     =  0
                      Psychomotor Overloads   =  0

Total Number of Overload Lines = 0
Total Number of Lines = 130

Overload Density =   0.0%
```

AH-64 Apache Task Analysis / WorkLoad Model
Segment Number: 42
Segment Title: Engagement, LOBL / Remote Designation

Subsystem Overloads	PILOT (P)	GUNNER (G)
A - Armament Subsystem		
AFC Fire Control Computer	0	0
AGC Gun Control	0	0
AL Laser	0	0
AMC Missile Control	0	0
ARC Rocket Control	0	0
ASG Symbol Generator	0	0
AW Weapons	0	0
E - Engine Subsystem		
EF Fuel	0	0
EE Engine	0	0
EIN Engine Instruments	0	0
EO Engine Oil	0	0
EI Ignition	0	0
F - Flight Control Subsystem		
FA Air Frame	0	0
FB Brakes	0	0
FC Flight Control	5	0
FI Flight Instruments	0	0
FG Gear	0	0
FH Hydraulics	0	0
FR Rotor	0	0
FT Transmission	0	0
N - Navigation Subsystem		
NM Maps	0	0
NC Navigation Control	0	0
ND Navigation Display	0	0
S - Safety Subsystem		
SG Ground Security	0	0
S Safety	0	0
U - Utility Subsystem		
UAD Advisory	0	0
UAI Anti-Ice	0	0
UAP APU	0	0
UC Communications	5	0
UEL Electrical	[illegible]	0
UEN Environmental	0	0
UF Flight Forms	0	0
UL Lighting	0	0
US Survivability	5	0
UV Video	0	0
V - Visual Subsystem		
VEX External Visual Field	5	0
VSC Sensor Control	0	0
VSD Sensor Display	2	0
VVD Visual Display	0	0

Segment Number: 7
Segment Title: Contour Flight (Threat) [NVG]
April 27, 1989

```
Function  25: average times = 15,  ceiling = 23,  performed =  8,  remaining = 15

Function   3: average times =  5,  ceiling =  8,  performed =  5,  remaining =  3

Function  18: average times =  5,  ceiling =  8,  performed =  7,  remaining =  1

Function  55: average times =  1,  ceiling =  2,  performed =  1,  remaining =  1

Function  63: average times =  3,  ceiling =  5,  performed =  2,  remaining =  3

Function  58: average times = 30,  ceiling = 45,  performed = 23,  remaining = 22
```

4. NUMERICAL DATA FILE

0.0	1.0	0.0	3.0	3.0	0.0
0.5	1.0	4.0	4.0	2.0	4.0
1.0	1.0	4.0	1.0	2.0	4.0
1.5	1.0	4.0	1.0	2.0	4.0
2.0	1.0	0.0	3.0	3.0	0.0
2.5	1.0	1.0	1.0	4.0	1.0
3.0	1.0	1.0	1.0	4.0	1.0
3.5	1.0	1.0	1.0	4.0	1.0
4.0	1.0	1.0	1.0	4.0	1.0
4.5	1.0	1.0	1.0	4.0	1.0
5.0	1.0	1.0	1.0	4.0	1.0
5.5	1.0	0.0	0.0	1.0	0.0
6.0	1.0	0.0	3.0	3.0	0.0
6.5	1.0	1.0	1.0	4.0	1.0
7.0	1.0	1.0	1.0	4.0	1.0
7.5	1.0	1.0	1.0	4.0	1.0
8.0	1.0	1.0	1.0	4.0	1.0
8.5	1.0	1.0	1.0	4.0	1.0
9.0	1.0	1.0	1.0	4.0	1.0
9.5	1.0	0.0	0.0	1.0	0.0
10.0	1.0	4.0	1.0	2.0	4.0
10.5	1.0	0.0	3.0	3.0	0.0
11.0	1.0	0.0	3.0	3.0	0.0
11.5	1.0	0.0	3.0	3.0	0.0
12.0	1.0	0.0	3.0	3.0	0.0
12.5	1.0	4.0	4.0	2.0	4.0
13.0	1.0	0.0	3.0	3.0	0.0
13.5	1.0	1.0	1.0	4.0	1.0
14.0	1.0	1.0	1.0	4.0	1.0
14.5	1.0	1.0	1.0	4.0	1.0
15.0	1.0	1.0	1.0	4.0	1.0
15.5	1.0	1.0	1.0	4.0	1.0
16.0	1.0	1.0	1.0	4.0	1.0
16.5	1.0	0.0	0.0	1.0	0.0
17.0	1.0	4.0	4.0	2.0	4.0
17.5	1.0	4.0	1.0	2.0	4.0
18.0	1.0	4.0	2.0	6.0	4.0
18.5	1.0	4.0	1.0	2.0	4.0
19.0	1.0	4.0	4.0	2.0	4.0
19.5	1.0	4.0	1.0	2.0	4.0
20.0	1.0	4.0	1.0	2.0	4.0
20.5	1.0	4.0	2.0	6.0	4.0
21.0	1.0	4.0	2.0	6.0	4.0
21.5	1.0	4.0	1.0	2.0	4.0
22.0	1.0	0.0	3.0	3.0	0.0
22.5	1.0	4.0	1.0	2.0	4.0
23.0	1.0	4.0	1.0	2.0	4.0
23.5	1.0	0.0	3.0	3.0	0.0
24.0	1.0	0.0	3.0	3.0	0.0
24.5	1.0	4.0	1.0	2.0	4.0
25.0	1.0	4.0	4.0	2.0	4.0
25.5	1.0	4.0	4.0	2.0	4.0
26.0	1.0	0.0	3.0	3.0	0.0
26.5	1.0	4.0	1.0	2.0	4.0
27.0	1.0	4.0	1.0	2.0	4.0
27.5	1.0	4.0	1.0	2.0	4.0
28.0	1.0	0.0	3.0	3.0	0.0
28.5	1.0	4.0	1.0	2.0	4.0

5. TASK LISTING

Segment Number: 42
April 26, 1989
Segment Title: Engagement, LOBL / Remote Designation

```
 0.0  640: Check Weapon Path
       66: Monitor Audio
 0.5  439: Maintain Obstacle Clearance
       66: Monitor Audio
 1.0  160: Control Drift
       66: Monitor Audio
 1.5  305: Control Heading
       66: Monitor Audio
 2.0  640: Check Weapon Path
       66: Monitor Audio
 2.5   66: Monitor Audio
      691: Monitor Flight Controls
      148. Check Direction Display
 3.5   66: Monitor Audio
      691: Monitor Flight Controls
      148: Check Direction Display
 4.5   66: Monitor Audio
      691: Monitor Flight Controls
      148: Check Direction Display
 6.0  640: Check Weapon Path
       66: Monitor Audio
 6.5   66: Monitor Audio
      691: Monitor Flight Controls
      148: Check Direction Display
 7.0   66: Monitor Audio
      691: Monitor Flight Controls
      148: Check Direction Display
10.0   36: Control Altitude
       66: Monitor Audio
10.5  640: Check Weapon Path
       66: Monitor Audio
12.5  439: Maintain Obstacle Clearance
       66: Monitor Audio
13.0  640: Check Weapon Path
       66: Monitor Audio
13.5   66: Monitor Audio
      691: Monitor Flight Controls
      148: Check Direction Display
17.0  439: Maintain Obstacle Clearance
       66: Monitor Audio
17.5  160: Control Drift
       66: Monitor Audio
18.0  591: Monitor Time (Inflight)
       66: Monitor Audio
18.5  305: Control Heading
       66: Monitor Audio
```